

**PLANTATION TECHNOLOGY FOR NINE INDIGENOUS
TREE SPECIES OF KERALA**

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Peechi-680653, Kerala
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(Final Report of the Project KFRI 343/2000, April 2000 to March 2002)

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**Project sponsored by the Kerala Forest Department
under the World Bank aided Kerala Forestry Project**



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Abstract of Project Proposal

1. Code : KFRI 343/2000
2. Title : **Plantation technology for nine indigenous tree species of Kerala**
3. Principal Investigator : **K.K.N. Nair**
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5. Objectives : To generate data on seed, nursery and plantation aspects of the nine indigenous tree species, including protection from pests and diseases at different stages of plantation establishment.

To establish pilot scale plantations of the species with propagules collected from forest trees, to evaluate the field performance of each of them and transfer the technology developed to the Forest Department.

To prepare a detailed report on the plantation aspects of the species studied and to publish package of plantation practices for all the nine species in the form of Information Bulletins.
6. Expected outcome : Exhaustive data on the plantation aspects of the nine indigenous tree species

Package of plantation practices for all the nine species

Demonstration cum data source on native species plantation in the State
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Abstract

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ABSTRACT

To standardize the plantation technology of nine selected indigenous tree species of Kerala, namely *Calophyllum polyanthum* Wall. ex Choisy (*C. elatum* Bedd.), *Dysoxylum malabaricum* Bedd. ex Hiern, *Garcinia gummi-gutta* (L.) Robson (*G. cambogia* (Garten.) Descr.), *Gmelina arborea* Roxb., *Grewia tiliaefolia* Vahl, *Haldina cordifolia* (Roxb.) Ridsd., *Lagerstroemia microcarpa* Wt., *Melia dubia* Cav. and *Vateria indica* L., data were generated on the seed, nursery and plantation aspects of each of the species. Nursery trials were done at the Institute's Field Research Centre, (FRC), Veluppadam and at the main Campus at Peechi. Plantation trials were conducted at two locations; for evergreen species, namely *C. polyanthum* and *D. malabaricum*, in an evergreen forest area (Kollathirumedu Range in Vazhachal Forest Division) and for the remaining seven moist deciduous species, in the moist deciduous forest area of FRC, Velupadam in Palappilly Range of Trichur Forest Division. During different stages of the plantation trial, pest and disease problems in seeds, nursery and field-planted seedlings were also monitored, and wherever such damages were serious, control measures were standardized. An attempt was made to standardize root-trainer and vegetative propagation methods for different species and the details are incorporated in the report.

The plantation trial had shown that, in the case of *C. polyanthum*, seedlings can be raised from seeds without any pre-treatment or by vegetative propagation and pest and disease problems are not serious. It is noted that, plantations of the species can be raised in evergreen forest areas of the State with the technology evolved. For *Dysoxylum malabaricum*, seeds available from natural stands are much affected by the *Daccus* pest and therefore pest free seeds are to be collected. Even though germination percentage is low, seeds without any pre-treatment is the best source to raise seedlings as the vegetative propagation method tried was not promising in propagule production. There is no major pest or disease incidence in the nursery and plantation stages of the species and plantations of it can be raised in evergreen forest areas. *Garcinia gummi-gutta* can also be regenerated artificially from the seed source, which gives 82.5 per cent germination, when sown after removal of the seed coat. In the case of *Gmelina arborea*, rooted cuttings is a potential source of propagules for planting, even though seeds collected from the droppings of deer gave 94 per cent germination. If seeds are used for the production of seedlings, it is better to sow them in polypots or root-trainers to avoid pricking and potting impacts. Disease and pest problems, not very severe in the species at seed, nursery and plantation stages, can be managed and the species comes up well in moist deciduous forest areas. The moist deciduous species *Grewia tiliaefolia* can also be raised on a large scale from seeds, even though germination of seeds is maximum during the 10th month of sowing. An attempt to root juvenile stem cuttings of the species has also proved successful and there is no potential disease or pest problem in the seed, nursery and plantation phases of the species. *Haldina cordifolia* produces ample seeds which can be sown in polyurethane foams and later on pricked into polypots or root-trainers filled with vermiculite or compost (mixed weed or coir pith). Damping-off disease in very young seedlings is a major problem in the large-scale production of seedlings of the species, which can

be controlled by the application of fungicides. In the case of *Lagerstroemia microcarpa*, the minute seeds can be sown in trays rather than in nursery beds with fungicidal pre-treatment to check damping-off disease. From seed source, only 17 per cent seedling production was recorded, whereas vegetative propagation using juvenile stem cuttings gave 60 per cent; root-trainer method was also successful (32%). When planted in moist deciduous forest areas, about 49 per cent seedlings survived and grazing by wild animals like deer in natural forest areas is perhaps a practical difficulty in the establishment of plantations of the species. Seed germination in the case of *Melia dubia* is very poor and therefore, rooted cuttings can be a better alternative to raise plantations of the species. There is no potential pest or disease problems for the species, which can grow well in moist deciduous forest areas with sufficient shade during the initial stages of establishment. Among the nine species tried, *Vateria indica* is the most potential species as far as plantation growth and seed germination is concerned, even though survival percentage of field-planted seedlings is only 62 which has to be improved by providing shade during the first summer after field-planting. When the nine species were graded for their plantation potential, *G. arborea* comes first followed by *C. polyanthum*, *G. gummi-gutta*, *G. tiliaefolia* and *L. microcarpa*. The other four species namely *D. malabaricum*, *H. cordifolia*, *M. dubia* and *V. indica* showed certain drawbacks which need more attention from silvicultural point of view. As part of this study, separate 'Package of practices' on the plantation technology of the nine species have been prepared.

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1. INTRODUCTION

In the natural forests of Kerala, there are several indigenous tree species yielding wood, which can be used for various purposes. At present, the only source of timber of those species is from the natural forests. Moreover, many of the traditionally used timbers of indigenous tree species are also becoming very scarce, resulting in escalation of their prices. One of the reasons for the scarcity is that, only very few of these species are grown artificially, either on a large scale as forest plantations or on a small scale, in homesteads or wastelands, wherever possible. In fact, traditional production forestry in India is focused much on the monoculture of a few species like teak, eucalypts, pines, poplars, etc. aimed at producing timber, mainly for industrial consumption, and sometimes for limited domestic uses, and therefore, Evans (1982) had rightly pointed out that almost 85 per cent of the forest plantations in the tropics are of eucalypts, pines or teak. Kerala State is also no exception to this. The two major reasons for this species preference in plantation forestry are: 1, such species meet the raw material demand of industries like paper and pulp and to, enough scientific data are available on their plantation technology. Yet another reason for not establishing plantations of native species is that, in the past, there were adequate supplies of timber of indigenous tree species from the natural forests, and therefore, there was no need to grow them artificially to meet the demand. However, currently there is an increasing tendency to grow indigenous tree species on a plantation scale. The Kerala Forest Department had already raised small plantations of *Dalbergia latifolia* (Rosewood), *Dalbergia sissooides* (Malabar Blackwood), *Artocarpus integrifolius* (Anjili), etc. even though such species lacked plantation data generated for Kerala conditions. The added advantages of indigenous tree species in plantation forestry are that they are environmentally more safe and also user friendly, which are very important aspects, especially in the present context, when any large or small scale plantation programme is initiated.

This study aimed at standardizing the plantation technology of nine indigenous tree species of Kerala, namely *Calophyllum polyanthum* Wall. (Kattupunna), *Dysoxylum malabaricum* Bedd. (Vella-akil), *Garcinia gummi-gutta* (L.)

Robson (Kodam-puli), *Gmelina arborea* Roxb. (Kumbil), *Grewia tiliaefolia* Vahl (Chadachi), *Haldina cordifolia* (Roxb.) Ridsd. (Manja-kadambu), *Lagerstroemia microcarpa* Wt. (Ven-thekku), *Melia dubia* Cav. (Mala-veppu) and *Vateria indica* L. (Vella-payin). Among them, *Calophyllum polyanthum* and *Dysoxylum malabaricum* are species of the evergreen forest habitat whereas the remaining seven species grow naturally in the moist deciduous forest tracts of the State (Fig. 1.1). *Garcinia gummi-gutta* is also grown in the homesteads of Kerala for its fruits, used in food preparations. All the nine tree species selected for the study



Fig. 1.1. Natural forests of Kerala - the habitat of indigenous tree species

are timber yielding, and the wood of *Garcinia gummi-gutta* with high calorific value, is much preferred as firewood, even though it is grown in homesteads for its fruits, processed and consumed or marketed as a food product.

1.1. Review of literature

Published data on the plantation technology with regard to the nine indigenous tree species selected for investigation are rather very scanty. However, Troup (1921) in his work entitled the *Silviculture of Indian Trees* and its revised editions brought out by the Forest Research Institute, Dehra Dun (FRI, 1975-

85) presents certain amount of information on the silvicultural aspects of hundreds of indigenous tree species of the country and subsequently Luna (1996) also attempted to present exhaustive details on the artificial regeneration of a few selected indigenous and also exotic tree species found in India. In all these references, exhaustive data on the plantation aspects of the species studied are lacking, especially in the Kerala context, with the exception of *Gmelina arborea*, which is known better in the plantation context. Even though, not covering all the different aspects of plantation establishment, Prasad and Kandya (1992) gave details on handling of forest seeds in India. Bhodthipuks *et al.* (1996) dealt with the seed viability of many tropical trees and Chacko *et al.* (2002) gave seed handling methods and nursery practices of a few forest trees of Kerala. Dent (1948) confined his work to the storage aspects of forest tree seeds and Hong and Ellis (1996, 1998) generated details on the seeds in storage. Same is the case with Karivaradaraju *et al.* (1999) who worked on seed technology. Sengupta (1937) standardized seed weight and germination rate of several indigenous species of the country. Similarly, pest and disease problems associated with indigenous tree species in natural habitats and in the context of artificial regeneration were dealt with by Beeson (1941), Browne (1968), Mittal and Sharma (1982), Mohanan and Varma (1988), Mohanan and Sharma (1991), Sensarma *et al.* (1994), Sharma and Mohanan (1980), Sharma *et al.* (1985), and so on. A few specific scientific studies on plantation aspects are also available on Sandal (Srimathy *et al.*, 1992), *Adenantha pavonina* (Koirala *et al.*, 2000), Portiza tree (Kadher and Chacko, 2000), and so on. In order to assess the plantation potential of indigenous tree species, Qureshi (1986) had brought out details regarding the concept of fast growth, very useful for assessing the potential of species tried in plantation forestry.

Recently, Rai (1999) published the nursery and plantation aspects of a few forest tree species of tropical South-East Asia, wherein, most of the species covered in the present study are also included. However, basic data on seeds and their processing techniques, experimental data on nursery, pests and diseases in seed, nursery and out-planted seedlings and growth aspects in plantation trials given are rather scanty and pertains only to Karnataka

conditions. In fact, more thrust is given there on the root characters of the seedlings of different indigenous tree species with the help of illustrations. A detailed publication on various aspects of the plantation of six selected indigenous timber tree species of Kerala was brought out by Nair *et al.* (1991) in which seed, nursery and plantation aspects of *Albizia odoratissima*, *Grewia tiliaefolia*, *Lagerstroemia microcarpa*, *Pterocarpus marsupium*, *Haldina cordifolia* and *Xylia xylocarpa* were standardized, both for their pure plantations and also 25 percent and 50 percent mixtures among them. The trial experiment conducted also concluded that indigenous species like *Haldina cordifolia*, *Lagerstroemia microcarpa* and *Pterocarpus marsupium* are fast growing species, both in monoculture and also in mixtures. Detailed data on pest and disease problems in fresh seed samples, stored seeds, nursery seedlings and out-planted propagules were also generated during the study, apart from basic data on within species variation, natural distribution, ecology and also timber qualities, wood characteristics and uses. However, in the present experiment, three of the above mentioned species of *Grewia*, *Haldina* and *Lagerstroemia* were included for which additional information on vegetative propagation and root-trainer technology was generated. The data generated during the study were also compared with the earlier findings.

2. OBJECTIVES

The present study envisages to work out the plantation technology of nine indigenous tree species to meet the data requirements of Kerala Forest Department and other agencies. The specific objectives of the programme are:

- To generate data on seed, nursery and plantation aspects of the nine indigenous tree species, including protection from pests and diseases at different stages of plantation establishment.
- To establish pilot scale plantations of the species with propagules collected from forest trees, to evaluate the field performance of each of them and transfer the technology developed to the Forest Department.
- To prepare a detailed report on the plantation aspects of the species studied and to publish package of plantation practices for all the nine species in the form of Information Bulletins.

The species selected for the study are *Calophyllum polyanthum* (Kattupunna), *Dysoxylum malabaricum* (Vella-akil), *Garcinia gummi-gutta* (Kodampuli), *Gmelina arborea* (Kumbil), *Grewia tiliaefolia* (Chadachi), *Haldina cordifolia* (Manja-kadambu), *Lagerstroemia microcarpa* (Ven-thekku), *Melia dubia* (Mala-veppu) and *Vateria indica* (Vella-payin). Out of the nine species (Figs. 2.1-2.9) included in the study, eight were selected when the project was initiated during 2000, and *Melia dubia* was added later (during April 2001), as suggested in one of the review meetings of the project. Also, root-trainer technology was tried for five species excepting species of *Calophyllum*, *Dysoxylum*, *Garcinia* and *Vateria* and vegetative propagation was tried for all the nine species, as suggested in one of the review meetings.

3. METHODOLOGY

Basic information

Up-to-date nomenclature of all the nine species was worked out in accordance with the *International Code of Botanical Nomenclature* (2000) and a few synonyms are included in the nomenclature part by which the species are known in National (Hooker, 1871-96), Regional (Gamble, 1915-1935) and State (Rama Rao, 1914; Bourdillon, 1902) Floras. Local names used for the species were gathered from literature and also during field and herbarium studies. A brief description of each species is prepared based on fresh collections and by literature scrutiny, giving details of habit, leaves, inflorescence, flowers, fruits and seeds. Data on flowering and fruit ripening periods were also gathered based on field and herbarium data. The natural distribution pattern of each of the species in the forests of Kerala was gathered from field, herbarium studies and literature, along with their world distribution pattern, available in literature. As the species investigated are timber trees, details on the log quality were also gathered from their natural stands in the forests of Kerala. Wood characteristics like density, grain, texture, etc. were mostly gathered from references like Nazma *et al.* (1981) dealing with Kerala timbers.

While, evolving data on the plantation aspects of the nine species, data were generated on the production of planting stock of various species with seeds

sown in nursery beds (12 m x 1.2 m) or polypots (23 cm x 1.7 cm) filled with potting medium with mixed weed compost (compost 8 : soil 1 : sand 1) or coir-pith compost (compost 3 : soil 1) and rooting of stem cuttings using the rooting

Table 3.1. Details of trials conducted for nine species using seeds in bed, root-trainers and stem cuttings

Species	Seed-bed	Root-trainer	Vegetative
<i>Calophyllum</i>	+	-	+
<i>Dysoxylum</i>	+	-	+
<i>Garcinia</i>	+	-	+
<i>Gmelina</i>	+	+	+
<i>Grewia</i>	+	+	+
<i>Haldina</i>	+	+	+
<i>Lagerstroemia</i>	+	+	+
<i>Melia</i>	+	+	+
<i>Vateria</i>	+	-	+

hormone Indole Butyric Acid (IBA) in 3000 ppm, 4000 ppm and 5000 ppm. Details of the trials conducted (+) for different species and species for which root-trainer method could not be tried (-) due to lack of seed availability are given in Table 3.1.

Seed collection, processing and storage

From a scrutiny of herbarium specimens, literature and also based on field observations, localities of natural distribution of different tree species selected



Fig. 3.1. Processing of seeds for germination

for the study were gathered. With phenological data gathered from herbarium specimens and other reliable sources, ripened fruits of various species were collected from the natural forest areas of the State where the species are distributed and details of collection season recorded. While collecting the fruits, the criterion followed was to go for the most practical and

suitable method for getting sufficient quantity of quality seeds and the mode of collection was also recorded for each of the species. Any major pest or disease

attack of the fruits in the field was recorded, apart from their colour and other general morphological features and characteristics, including shape and size, from typical samples. Sufficient quantity of fruits was collected from the field, which were brought to the laboratory for processing and extraction of seeds for conducting the plantation trial experiment. Procedures were standardized for the extraction of seeds from ripened fruits and the seed samples for sowing in the nursery were separated, cleaned and dried in shade, wherever required. Information pertaining to preliminary stages of seed extraction, processing (Fig. 3.1) and storage was generated and all such data are provided species-wise in the report.

From fresh seed samples collected, details were also gathered on their size, shape and weight per kilogram (using an electronic balance). Different seed samples of each of the species were used for collecting preliminary details. Infection of seeds by pathogenic organisms and pest species was regularly monitored in fresh seed samples and also from those kept in storage. The organisms affecting the seeds were identified, level of attack assessed, and wherever required, suitable control measures were standardized and applied.

For seed pathological studies, seed samples were collected from forest areas during the seeding years 2000 and 2001. The pooled samples, soon after the collection, were labelled and brought to the laboratory in cloth bags. The seeds were sun/air dried to reduce the moisture content to about 10-15 per cent and stored separately in cotton bags at room temperature ($25-28 \pm 2$ °C). The standard blotter test recommended for seed testing was employed (ISTA, 1966). A random sample of 400 seeds was used for data collection of each species. In the case of *Garcinia gummi-gutta*, *Vateria indica* and *Gmelina arborea*, where the seeds are large sized, only 150 to 210 seeds were used. Wet sterilized blotters of 9 or 11 cm size were used in the study. The plates were incubated at 25 ± 2 °C under 12 hours of alternating cycles of light and darkness for 7 days and were examined on the 8th day with the help of a stereomicroscope for microbial growth. Relative percent incidence (RPI) of each microorganism was calculated using the following formula.

$$\text{RPI} = \frac{\text{No. of seeds with organism} \times 100}{\text{Total number of seeds tested}}$$

Common seed dressers like Mancozeb, Carbendazim, Captan, Hexathir and Carboxin were used (2 to 6 g/kg of seeds) in the study. Treated seeds, stored in plastic containers, were examined on the first day and 90 days after the treatment, employing standard blotter method. Observations were recorded on the 8th day of incubation. RPI of various microorganisms was calculated as mentioned earlier.



Fig. 3.2. Prepared standard nursery bed

For gathering data on seed pests, observations were made on fruits and seeds collected from natural stands for sowing in the nursery. For assessing the intensity of pest damage, random samples were taken from the seed lot and the number of affected seeds recorded and percent infestation calculated. Infected seeds were kept in the laboratory for observation on the nature and extent of damage by various pests. Infestation above 50 per cent was rated as heavy, 25-50 per cent as moderate and up to 25 per cent as mild.

Nursery techniques

Seeds were sown in standard nursery beds of 12 m x 1.2 m size, with shade-net (Fig. 3.2). The average quantity (weight) of seeds required for a standard nursery bed was also assessed. Samples of fresh and stored seeds were sown separately to assess the difference in germination rate. In the case of *Haldina cordifolia* and *Lagerstroemia microcarpa*, the seeds being very minute, plastic trays of 45 cm x 30 cm size were used for sowing. For *H. cordifolia*, the medium used for sowing was soaked foam and for *L. microcarpa*



Fig. 3.3. Plastic trays used for germination of minute seeds

vermiculite was used in the tray (Fig. 3.3). The duration taken by the seeds of different species to germinate was assessed separately and also the percentage of seeds which germinated and produced seedlings was calculated. The nursery beds were watered regularly to allow uninterrupted growth of seedlings.

Meanwhile, being tree species, polypots of 23 cm x 17 cm size filled with potting mixture were used to prick and pot the seedlings. The optimum number of days and the corresponding average size of seedlings at the time of potting were recorded and the potted seedlings were maintained in the nursery till the next rainy season, suitable for field planting (Fig. 3.4).

Infestation of seeds sown in the nursery bed/tray by pathogens was regularly monitored. So also, the tiny seedlings in the nursery affected by diseases were closely monitored for the causative organisms, level of infection



Fig. 3.4. Seedling maintained in nursery before field planting

and control measures taken wherever required. For this, seedlings of different species were raised in seedbeds or in polythene containers filled with soil and sand potting mixture at FRC, Velupadam, during July 2000. For the first 40-60 days, shade over the nursery was provided with shade net to protect the seedlings from sun scorch. The

seedlings were watered regularly and were maintained till the next planting season, i.e. South-West monsoon season, 2001, either in mother beds or in polythene containers. Occurrence of disease(s), if any, their symptoms and nature of damage caused to seedlings were recorded. The incidence of a disease was estimated either by counting the number of disease patches and approximate area covered by them or percent seedlings affected for a given density of seedlings in a seedbed. Appropriate parts of diseased seedlings were collected for isolation and identification of the causal organisms.

For gathering data on nursery pests, observations were made on seedlings raised on the standard nursery beds, in which five rectangular grids of the size 30 cm x 30 cm, were selected along diagonal transects within each bed, which formed the sampling unit. The number of healthy and affected seedlings within each grid and the nature of damage caused to them were recorded and the pooled average value was recorded as the percent infestation. Observations were repeated every month. Also, suitable management strategies were standardized based for the pest/pathogen and also the intensity of attack.

Wherever required, watering and moisture regimes of the nursery beds were regulated to avoid flourishing of the pathogens.

Root-trainer technology

Root trainers of 10 cm x 5 cm size were tried to germinate seeds and maintain the seedlings of various species. *Gmelina arborea*, *Grewia tiliaefolia*, *Haldina cordifolia*, *Lagerstroemia microcarpa* and *Melia dubia* were tried with this technology and for the remaining species viz. *Calophyllum polyanthum*, *Dysoxylum malabaricum*, *Garcinia gummi-gutta* and *Vateria indica* the technology could not be tried due



Fig. 3.5. Treating filled root trainers with fungicide before seed sowing

to lack of seed availability when the experiment was started. Two types of media were used in the root trainers, viz. mixed weed compost or coir pith compost. The mixed weed compost filled root-trainer samples were treated with the fungicide Carboxin (0.1 a.i.) and left for two days before sowing to prevent damage to seeds due to the chemical contents of the fungicide (Fig. 3.5). The mixed weed compost medium was prepared with 8 parts of the compost, 1 part of soil and 1 part of sand. For coir pith compost, 3 parts coir pith and 1 part soil were used. The composts were filled in root trainers and fresh seeds of *Gmelina*, *Grewia* and *Melia* were dibbled with 50 replicates for each sample. After germination, only one seedling was retained in one root trainer for recording growth data. Seeds of *Haldina*, being minute, were sown in wet polyurethane sheet placed in plastic trays of 50 cm x 50 cm and the seedlings were pricked into root trainers after 15 days of germination. The pathogens and pests associated with root trainer seedlings were isolated, identified and control measures worked out.

Vegetative propagation

Vegetative propagation using juvenile shoot cuttings was tried for all the nine species. The rooting hormone used was IBA (Indole Butyric acid) in three different concentrations, viz. 3000, 4000 and 5000 ppm. The hormone was prepared by mixing with talcum powder. Terminal portion of the seedlings,

branchlets and mature branches were used in the trial. For producing juvenile shoots, mature branch cuttings (20-30 cm diameter) were treated with the hormone in 5000 ppm concentration and planted in polythene bags of 32 cm x 28 cm, filled with soil-sand potting medium. The sprouts emerging from the branches were used for propagation. Root trainers of 10 cm x 5 cm, filled with vermiculite, were used as planting media. The terminal portion of the seedlings or branches with 2-3 nodes was removed and immersed in pure water. The leaf area of each cutting was reduced to half the size to reduce evapotranspiration. The prepared cuttings were kept in Carbendazim solution (1 g/1 litre) for 15 minutes to prevent fungal infection. The lower end of the cuttings was dipped in hormone and planted in root trainers. For each concentration of IBA, 24 replicates were prepared and therefore there were 72 samples for each species. The root trainers were kept in mist chamber. Intermittent misting was provided for rooting and sprouting. Relative humidity at 70-85 per cent and temperature between 30-35 °C were maintained inside the mist chamber. The rooting response shown by the cuttings in different concentrations of IBA was assessed and recorded.

Plantation techniques

Trial plantations of various species were raised during the South-West monsoon period and immediately after that, from June to November in 2001. The delay in planting was due to the seasonality of availability of seeds and raising seedlings



Fig. 3.5. Plantation trial area in Kollathirumedu evergreen forests

of plantable size. Seedlings of the two evergreen species, namely *Calophyllum polyanthum* and *Dysoxylum malabaricum*, were planted at Thottapura in Kollathirumedu Forest Range of Vazhachal Forest Division (Fig. 3.5). The plantation trial of the remaining seven moist deciduous species, namely *Garcinia gummi-gutta*, *Gmelina arborea*, *Grewia tiliaefolia*, *Haldina cordifolia*, *Lagerstroemia microcarpa*, *Melia dubia* and *Vateria indica* was conducted at the Institute's Field Research Centre at Veluppadam

(Fig. 3.6), from where, the coppice growth of teak and weed growth were removed as part of the site preparation activities.

The planting sites were aligned and staked at 2 m x 2 m spacing and pits of 30 cm x 30 cm x 30 cm size were taken. Seedlings of each of the species were planted in one block, and on an average, 500-600 seedlings were planted for each species, depending upon the length of different rows in each block. The plots were protected from fire and grazing by domestic animals. However, there was heavy grazing by wild animals like deer, which could not be controlled, and the seedlings much affected by grazing were those of *Gmelina arborea*, *Garcinia gummi-gutta*, *Lagerstroemia microcarpa* and *Melia dubia*. Survival and growth data of out-planted seedlings were gathered from the trial plots at three monthly intervals, since August 2001 to June 2002. However, in the case of *Haldina cordifolia* and *Melia dubia*, planting was delayed to November 2001, due to non-availability of seeds and therefore growth data could also be collected from that time onwards, till the end of the project in June, 2002.



Fig. 3.6. Moist deciduous plantation area in FRC, Veluppadam

The field planted seedlings were closely monitored for any pest or disease incidence. Being indigenous tree species, there were no major outbreak of pests or pathogens in the out-planted seedlings and those minor problems observed were recorded and monitored. Diseased specimens were collected and taken in separate polythene bags to the laboratory. Isolations were made within one week. Potato dextrose agar medium was used for isolation of fungi and nutrient agar for isolation of bacteria. Causal organisms were identified and the cultures were periodically subcultured and stored in cold room at 10 °C. For pathogenicity studies, seedling as well as detached leaf inoculation methods were employed. In the case of root, stem or shoot diseases of seedlings, pathogenicity was tested on seedlings raised in plastic trays (30 cm x 70 cm x 10 cm) or in root trainers. Standard procedures were followed to study the soil and seed-borne pathogens. Poison food technique and modified soil fungicide

technique (Zentmeyer, 1955; Sharma *et al.*, 1985) were used to evaluate various fungicides *in vitro* against the most important seedling disease causing pathogens.

During January 2002, when the summer season started, partial weeding and mulching were done in the planted area, as a routine measure to protect the seedlings. However, there were heavy casualties of field planted seedlings of species of *Garcinia*, *Melia* and *Vateria*, either due to delayed planting or because of severe drought, which is mentioned under various species in the plantation technology part. In the Report, results of the investigation are given species-wise with conclusions and recommendations on various aspects of the trial. For each species botanical nomenclature, local names, species description, distribution, phenology, log qualities, wood characteristics and uses, seed collection, processing and pre-treatments, seed sowing and germination, vegetative propagation details, root-trainer technology and plantation details like out-planting, survival and growth are given, along with details on pests and diseases at seed, nursery and planted seedlings stages of plantation establishment and their control are given. Illustrations of tree habit, fruits, seeds, seedlings in nursery and out-planted seedlings are also provided.

4. Results

4.1. CALOPHYLLUM POLYANTHUM

(Guttiferae)

Kattu-punna

Botanical nomenclature

Calophyllum polyanthum Wall. ex Choisy, Descr. Guttif. Ind. 43. 1849 & Mem. Soc. Phys. Hist. Nat. Genev. 12: 423. 1851. *Calophyllum elatum* Bedd., Fl. Sylvat. South-India t. 2. 1869. *Calophyllum tomentosum auct. (non Wt., 1839)* in Hook.f., Fl. Brit. India 1: 274. 1874 (*pro parte*).

Local names

Kattu-punna, Malam-punna, Punnappai, Viri.

Species description

Trees, 10-45 m tall; main trunk up to 1.5 m in girth; bark fissured, grey or brown coloured, flaking; branchlets, buds and inflorescence slightly tomentose.



Fig. 4.1.1. Tree of *C. polyanthum*

Leaves simple, margins undulate, entire, ovate to elliptic or oblong-lanceolate, obtuse, shiny, coriaceous, sparsely pubescent when young, acute or acuminate at apex, narrowed into the petiole at base. Inflorescence simple or panicles of terminal or axillary racemes, as long as the leaves. Flowers white, scented, polygamous; sepals 4, subequal, orbicular, concave; petals 4, spreading, obovate-oblong, concave; stamens numerous, yellow with filiform filaments, connate at base, and elliptic or oblong anthers; pistil with ovoid ovary, slender style and 2-3 lobed, peltate, stigma. Drupes yellowish or purple, about 2-3 cm x 1.5-2 cm, subglobose or ovoid to subovoid, smooth; seeds brown, elliptic or ovoid, enclosed in stones of 1.9-2.5 cm x 1.5-1.8 cm in size (Fig. 4.1.1).

Distribution

Semievergreen, evergreen and shola forests of Kerala; South-West and North-East India, Sri Lanka, Malesia, China.

Phenology

Flowers from January to May and fruits ripen during June to August, sometimes extending till November.

Timber, wood characteristics and uses*Log quality*

Logs large sized, straight and clean, up to 20 m length and 4 m girth. The timber kiln-season fairly well at low temperatures, with negligible surface cracking.

Wood properties and uses

The wood is reddish-white to pale reddish-brown with dark streaks and is interlocked or straight-grained, medium textured, strong, elastic and moderately durable. Specific gravity of the wood is about 0.51 and weight is about 655 kg/m³ (Nazma *et al.*, 1981). The wood is used mainly for railway sleepers, rafters, planking, low cost furniture, masts, poles, chests, mathematical instruments, bridges and in general construction work. It is a class-one plywood and Rama Rao (1914) had also reported the pulping quality of the wood.

From the bark of the tree, an astringent gum, soluble in cold water, is extracted (Chandrasena, 1935). The seed kernels contain about 70 per cent reddish-brown oil with an unpleasant odour, which solidifies at a temperature of about 25 °C. The oil is used as an illuminant.

PLANTATION TECHNOLOGY**Seed collection, processing and storage***Seed collection*

Even though, seeds ripen and fall on the forest floor during the first monsoon season in July-August, they will be often affected by borers or eaten away by monkeys, as the seeds are oily. Therefore, fruits can be gathered from the mother trees by lopping the terminal branchlets, when they ripen and become yellowish or dark-purple in colour. The fruits thus collected are to be depulped

and dried under shade before sowing. Fruits of light weight and small size are to be discarded during the processing period.

Seed characteristics

Mature fruits are drupaceous and ovoid or subovoid in shape, with an average size of 3.5 cm x 2.7 cm (Table 4.1.1). About 166-175 fresh fruits and 218-226 dried fruits weigh one kilogram. On an average, the seeds are 2.4 cm x 1.6 cm in size, elliptic in shape and brown in colour (Fig. 4.1.2). About 800-850 dried seeds weigh one kilogram (Table 4.1.1).



Fig. 4.1.2. Seeds of *C. polyanthum*

Seed storage

The dried seeds can be stored for less than six months without losing much viability (Rai, 1999). However, during the present study, they were sown within a month after collection to get maximum germination.

Table 4.1.1. Fruit and seed characteristics of *C. polyanthum*

	Colour	Shape	Size (cm)	No. per kg
Fruits	Yellowish purple	Ovoid	3.5 x 2.7	166-175
Seeds	Brown	Elliptic	2.4 x 1.6	800-850

Seed pests and control

The seeds fallen on ground were found to be infested by insect pests (shot-hole borers) and often monkeys also eat them away. Most damage was caused by shot-hole borers. The scolytidis *Coccotrypes* species and *Thamnurgides* species are known to affect the fruits of a variety of forest trees (Beeson, 1941). These insects generally start to attack while the fruits are on the mother trees. Regular collection and destruction of affected fruits have been suggested for managing the pest in seed stands. Care has to be taken to select fruits free from insect attack by checking and discarding the damaged ones.

Seed diseases and control

Seeds of *C. polyanthum* collected from Vazhachal, Vazhachal Forest Range and tested by blotter method showed five species of storage fungi, bacteria and actinomycetes (Table 4.1.2). Species of *Trichoderma*, *Aspergillus* and *Penicillium* were the most predominant fungi in non-surface sterilized seeds. Surface sterilization by 0.1% mercuric chloride reduced the incidence of seed microflora considerably. Seed treatment with Captan @ 4 g per kilogram of seeds also reduced incidence of spermoplane microflora. No seedling infection

Table 4.1.2. Spermoplane microorganisms detected on the seeds of *C. polyanthum* by blotter method and their relative per cent incidence (RPI)

Sl. No.	Microorganisms	RPI	
		NSS*	SS**
1.	<i>Aspergillus</i> spp.	12.00	
2.	<i>A. niger</i>	14.00	8.00
3.	<i>Chaetomium</i> sp	2.00	
4.	<i>Penicillium</i> spp.	12.00	2.00
5.	<i>Trichoderma</i> sp.	22.00	4.00
6.	Sterile mycelium	1.00	
7.	Bacteria	4.00	
8.	Actinomycetes	6.00	1.00

NSS: Non-surface sterilized; SS: Surface sterilized

caused by field fungi was observed in blotter test. Earlier, 11 spermoplane microorganisms from *C. polyanthum* seeds collected from Vazhachal, Sholayar and Edamalayar areas of Kerala State, in which *Fusarium* species causing seed and seedling rots is also included.

Seed processing and pre-treatments

The fruits gathered were depulped, spread out and dried in shade. Pretreatments conducted for the seeds include soaking of seeds in hot water (60-70 °C), boiling water (100 °C) and also immersing in concentrated Sulphuric acid (H₂SO₄) for 10 minutes to note the difference in germination

percentage (Table 4.1.3). Also, fruits as such were sown in the nursery beds to note the difference in germination between untreated and treated seed samples sown in the nursery bed.

Table 4.1.3. Details of processing and germination of seeds of *C. polyanthum*

Seed sample	No. of seeds sown/bed	Duration of treatment	Quantity required/bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Dried seeds in nursery bed	887	Sun dried for 2 weeks	1.1 kg	10 days	30 days	417	47
Dried seeds in polypots	842	Sun dried for 2 weeks	1 kg	20 days	45 days	383	45.5
Seeds soaked in water	200	24 hours	0.25 kg	25 days	35 days	26	13
Seeds soaked in hot water (60-70°C)	200	1 hour	0.25 kg	Nil	Nil	0	0
Seeds soaked in boiling water	200	10 minutes	0.25 kg	Nil	Nil	0	0
Seeds dipped in concentrated H ₂ SO ₄	100	1 hour	0.13 kg	Nil	Nil	0	0
Dried fruits sown as such	452	Sun dried for 2 weeks	2.65 kg	95 days	150 days	95	21

Nursery techniques

Seed sowing

Seeds were sown in standard nursery beds at a distance of about 10 cm, in drilled lines taken 15 cm apart. Also, samples were sown in polythene bags of 23 cm x 17 cm size, filled with potting mixture, during September, 2000. About one kilogram of seeds is sufficient to sow in one standard nursery bed, and in the case of polypots, only one seed each was sown, because of the large size of seeds. A dried sample of fruits as such was also sown in polypots, to record the variation in germination percentage. The seeds and fruits sown were covered

with a thin layer of soil and sand mixture (1:3) and the shaded beds and pots were regularly watered.

Seed germination

Within 10 days, the seeds sown in the nursery bed started germination and the first germination in polypots was observed by about 20 days. Within 30 days, germination was completed in the nursery bed and by about 45 days in the polypot. In the samples sown in the bed without removal of fruit wall, it took about 3 months to start germination, which was completed within 6 months after sowing. Seedlings remained in the cotyledonary stage for 10-20 days in all the different samples tried for germination. Germination percentages and duration taken for germination by different samples are given in Table 4.1.3.



Fig. 4.1.3. Nursery seedling of *C. polyanthum*

As per the details gathered (Table 4.1.3), without any pre-treatment, fresh and dried seeds can be sown in the nursery beds or dibbled in polybags to raise seedlings of *Calophyllum polyanthum* (47% and 45.5% germination, respectively). It is also observed that frequent watering is necessary for the seedlings pricked and polypotted from the nursery bed (Fig. 4.1.3). This is because of the impact of pricking and potting, and in this context, it is better to dibble the seeds directly in polypots than sowing them in nursery beds to save almost all the seedlings produced.

Nursery pests and control

No serious pest problem was encountered in the seedlings of *C. polyanthum*, maintained in the nursery.

Nursery diseases and control

No major diseases were observed on *C. polyanthum* seedlings raised in seedbeds. However, minor leaf spots and leaf tip blight were recorded in 2-month-old seedlings. *Colletotrichum gloeosporioides* was the pathogen found associated with the leaf spot. The pathogen caused small circular to irregular

dark brown lesions on leaves, which often cause shot-hole formation. When the disease incidence is very low, control measures are not essential. *Alternaria alternata* and *Curvularia luntana* were the fungi found associated with the leaf tip blight. The infection starts from the leaf tip and proceeds towards the centre of the leaf blade. The infection appears as pale brown water-soaked lesions and later necrosis occurs and the affected parts become blighted. *A. alternata* seems to be the pathogen initially associated with the disease and *C. luntana* invades the necrotic tissues later. Fungicidal application was given (Dithane M-45 @ 0.1% a.i.) for controlling the leaf-tip blight and shot-hole diseases of seedling in the seedbeds.

C. polyanthum has not earlier been tried in forestry in the State and hence no disease has been recorded from this species. The genus covers more than 120 species and of these 14 species are found in India. *C. inophyllum* L. is the common species among these and a few pathogens like *Gloeosporium* sp., *Macrophoma calophylli* Syd., *Pestalotia calophylli* P. Henn., *Pestalotiopsis calabae* (West.) Stey., *Sirococcus calophylli* Syd. causing minor leaf infections have been recorded (Uppal *et al.*, 1935; Sydow *et al.*, 1916; Dube and Bilgrami, 1966) earlier.

Pricking and maintenance of seedlings

The seedlings raised in the shaded nursery bed can be pricked by about four months, when they attain an average height of 15 cm. The pricked seedlings were potted in polybags of 23 cm x 17 cm size, filled with potting mixture (1 sand: 3 soil). The pricked and potted seedlings (Fig. 4.1.4) are to be watered regularly at an interval of 2-3 hours. The polypotted seedlings can be maintained in the shaded nursery for about eight months with regular watering, before out-planting, when they attain an average height of 17.5 cm. It was also observed that, if the nursery is established in an evergreen area, the seedlings perform better and attain an average height of about 32 cm within eight months period.



Fig. 4.1.4. Polypotted seedling of *C. polyanthum*

Root trainer technology

As seeds of *C. polyanthum* were not available during March to May, 2002, root-trainer technology could not be tried for the species. However, dibbling seeds in polypots filled with potting mixture was tried and found successful and therefore, raising seedlings in root-trainers containing mixed weed or coir pith compost can also be probably an easier method to raise seedlings.

Vegetative propagation

Trials were conducted to vegetatively propagate *C. polyanthum* using the rooting hormone IBA in three concentrations, viz. 3000 ppm, 4000 ppm and 5000 ppm (Fig. 4.1.5). Juvenile stem cuttings, branchlets and mature branches were tried for rooting and sprouting. The hormone treated samples were planted in vermiculite filled root trainers, each having 24 replicates in all the three IBA concentrations. It is observed that the species is responding well as far as rooting is concerned and about 75 per cent of treated samples with 4000 ppm IBA rooted in the vermiculite medium. The rooted cuttings are kept for hardening before field-planting.



Fig. 4.1.5. IBA treated cuttings of *C. polyanthum*

Plantation method

Out-planting of seedlings

Being a tree of the evergreen forests of Kerala, the plantation trial was also conducted in an evergreen forest area. For this, an open area was located within the evergreen forests of Vazhachal Division, at Thottapura in Kollathirumedu Range. The area was cleared off the miscellaneous growth of secondary species like *Macaranga* and weeds like *Mikania*, whereas fallen and deteriorating logs in the area were retained there itself. The area was aligned and staked at 2 m x 2 m spacing and pits of 30 cm x 30 cm x 30 cm size were taken. The potted seedlings (520 numbers) were field



Fig. 4.1.6. An out-planted seedling of *C. polyanthum*

planted (Fig. 4.1.6) by the onset of South-West monsoon during June, 2001. The polythene cover was removed without much disturbance to the soil around the roots of the seedlings and the empty covers were hanged on the stakes fixed at each pit-point, to facilitate location of the planted seedlings for further data collection.

Survival of seedlings

The survival of field-planted seedlings was monitored every month and those few seedlings perished during the first month were also replaced. After a period

Table 4.1.4. Details of survival and growth of out-planted seedlings

Month of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	466	54	89.62	18.3
6 months	359	161	69	18.7
9 months	255	265	49	18.9
12 months	203	317	39	20

of 12 months, almost 39 per cent of the seedlings survived. During the first three summer months (January-March, 2002), there was heavy casualty due to drought, which brought down the survival to 49 per cent from 95 per cent after one month of planting. The details on number of seedlings planted and the number survived and average growth recorded are given in Table 4.1.4.



Fig. 4.1.7. Leaf feeding by caterpillars

Plantation pests and control

Profuse leaf feeding by a lymantrid caterpillar (Fig. 4.1.7) was observed in the balance seedlings maintained at Peechi after planting. However, no such incidence was noticed in the plantation raised at Kollathirumedu. Application of 0.1% Ekalux 25 EC (Quinalphos) was found effective to control the caterpillar.

Plantation diseases and control

Leaf-spot disease caused by *Colletotrichum* state of *Glomerella cingulata* was observed in field-planted seedlings. The disease was noticed during the rainy season of August-September and it affected only few plants. Under the high humid conditions prevailing at the plantation site, the leaf spots often spread to almost the entire leaf blade, especially those of younger leaves. Infection was found restricted in spread in older leaves and occasionally formed shot-holes. *Meliola* species causing sooty mold infection was also found on both upper and lower surfaces of the leaves of a few out-planted seedlings. As the infection was noticed on the upper surface of the leaves it may reduce the photosynthetic efficiency of the plants. However, as the attack was mild no control measures were taken in the field.

Growth of seedlings

Within a period of 12 months (July 2001 to June 2002), the out-planted seedlings registered an average height of 20 cm.

Conclusions and recommendations

The seeds of *Calophyllum polyanthum*, free from pest attack, are to be collected from the field. Without any pretreatment about 47 per cent of the seeds germinate in seed-beds and this was 45 per cent in polypots. In order to avoid the impact of pricking and polypotting from nursery beds, it is recommended that the seeds may be dibbled in polypots filled with potting mixture or root trainers filled with mixed weed compost or coir pith compost. Attempt to root juvenile stem cuttings by hormone treatment at three concentrations was also successful with 75 per cent of the 4000 ppm IBA treated samples rooting in deep vermiculite medium. Therefore, seedlings can be generated on a large scale from the seed source in polypots filled with potting mixture, root trainers with mixed weed or coir pith compost or by vegetative propagation. No serious pest or disease incidence was recorded on seed, nursery and plantation stages of the species. However, being a species of the evergreen forests, the seedlings when out-planted require dense shade. Growth of the species is rather slow, as observed during the first 12 months of the plantation trial when the seedlings attained only an average height of 20 cm in the field.

4.2. DYSOXYLUM MALABARICUM

(Meliaceae)

Vella-akil

Botanical nomenclature

Dysoxylum malabaricum Bedd. ex Hiern in Hook.f., Fl. Brit. India 1: 548. 1875. *Dysoxylum glandulosum* Talbot, Syst. List Trees Bombay 39. 1894.

Local names

Vella-akil, White cedar.

Species description

Evergreen trees, up to 35 m high with a maximum girth of about 2.5 m; bark smooth, grey with white warts. Leaves alternate, imparipinnate, pale green; leaflets 9-11, obovate or oblong, entire, cartaceous, glabrous, abruptly acuminate at apex, cuneate at base. Inflorescence axillary, pubescent panicles. Flowers white, fragrant, hermaphrodite, crowded towards the end of panicles; sepals 4 lobed, obtuse; petals 4, linear-oblong, imbricate, pubescent outside; stamens 8, filaments united into a staminal tube, often more or less 4 angled with 8 included anthers; pistil with ovary embedded in the cup-shaped disc, white-tomentose, 4-locular with 2 collateral ovules in each cell, long style and capitate stigma. Capsules bright yellow, pyriform, longitudinally furrowed, verrucose; seeds 3-4, reddish brown, bluntly trigonous (Fig. 4.2.1).



Fig. 4.2.1. A tree of *D. malabaricum*

Distribution

Evergreen forests of Kerala; endemic to the Western Ghats of Peninsular India from Karnataka southwards.

Phenology

Flowering from February to May and fruits ripen during May to July.

Timber, wood characteristics and uses

Log quality

The logs are straight and cylindrical and about 25 m in length and up to 1.5 m in girth.

Wood properties and uses

The sapwood is whitish or greyish yellow and the heartwood is yellow, golden yellow or yellowish brown. The wood is moderately hard and heavy, i.e. 720 kg/m³ (Nazma *et al.*, 1981). The wood is fine textured and straight or somewhat interlock grained. It is easy to season and also to saw and takes polish very well.

The quite durable wood is used in construction work, decorative panelling and as aircraft plywood. Also, furniture, tool handles, artificial limbs and other rehabilitation aids, textile mill accessories, engineering instruments, etc are made of White cedar. The wood oil a remedy for ear and eye diseases and a decoction of wood is used in the treatment of rheumatism.

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection

The fruits of *D. malabaricum* ripen during May to July and fall on the ground. They can be collected either from standing trees or those fallen on the ground.



Fig. 4.2.2. Fruits of *D. malabaricum*

However, the fruits on standing trees and also fallen ones are often heavily attacked by a Dipterean pest belonging to the genus *Dacus*. From the very early stage of development, the seeds are infested by the pest and therefore care should be taken to ensure that the fruits collected for the extraction of seeds are not pest attacked. The fruits are 3-4 seeded. The ripened

fruits fallen on the ground soon germinate turning the cotyledons green, and at that time, if such green ones are gathered, then there will not be any pest

problem, whereas, those ripe fruits which are black and mouldy in the damp weather will rot and perish.

Seed characteristics

The ripened fruits are oval or pear shaped, greenish-yellow or yellow in colour, and on an average, 5.5 cm x 6 cm in size (Fig. 4.2.2). About 10-12 fruits weigh one kilogram. The seeds are subglobose in shape, reddish brown in colour, with an average size of 3.5 cm x 2.4 cm, and in one kilogram, there will be about 124-128 seeds (Table 4.2.1). Troup (1921) reported up to 212 seeds in a kilogram and Sengupta (1937) noted 121 seeds per kilogram. However, Rai (1999) reported about 400 seeds per kilogram, which appears to be a very high figure as far as samples from Kerala State are concerned.



Fig. 4.2.3. Seeds of *D. malabaricum*

Seed storage

Seeds of *D. malabaricum* lose their viability on storage and it is recorded that storing in gunny bags for 10-15 days brings down the viability to about 2 per cent (Troup, 1921). Rai (1999) also recorded that the viability of stored seeds

Table 4.2.1. Fruit and seed characteristics of *D. malabaricum*

	Colour	Shape	Size (cm)	No. per kg
Fruits	Bright yellow	Verrucose, longitudinally lined	5.5 x 6	10-12
Seeds	Reddish brown	Bluntly trigonous	3.5 x 2.4	124-128

is very low. Even though, Dent (1948) reported that the seeds can be stored in wet gunny bags for six weeks, it is better that, seeds collected from forest areas be brought to the nursery site without much delay and sown, as early as possible.

Seed pests and control

Heavy attack by tephritid flies (*Daccus* sp.) is noted in the seeds of *D. malabaricum*. The immature stages of this fly feed on the inner portion of the fruits (Fig. 4.2.4). Species belonging to this genus are known to be extremely

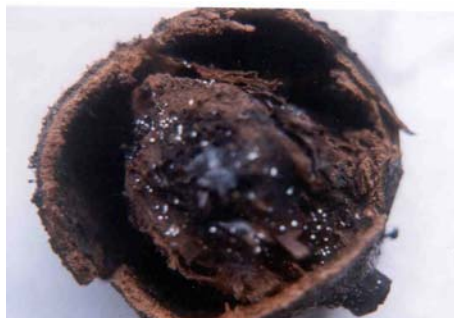


Fig. 4.2.4. Attack of *Daccus* sp. on seeds of *D. malabaricum*

injurious, wherever they are established. The eggs are deposited inside the fruits and the whole lifecycle takes place within about 30 to 40 days and pupation occurs on the ground. The seeds get affected early and the infestation is not detectable during the initial stages. Only when the fruits mature, signs of infestation occur in the form of punctures or

exudation of gum. At this stage no control measures can save the seeds, since the insects, which develop inside the fruits, might have already eaten away the seeds. Collection of seeds at the right season from trees, relatively free from pest attack, seems to be the most practical way to tide over this situation.

Seed diseases and control

D. malabaricum seeds harboured 12 fungi, mostly belonging to the group of storage molds (Table 4.2.2). Seeds collected from Charpa Forest Range of Vazhachal Division were used for the study. In blotter tests, non-surface sterilized seeds were found to harbour rich microflora than the surface sterilized seeds. Species of *Trichoderma*, *Aspergillus* and *Penicillium* were the most predominant fungi in non-surface sterilized seeds. *Alternaria*, *Fusarium*, *Curvularia* and *Verticillium* species were the fungi recorded on surface sterilized seeds. Seed rot caused by *Fusarium* species and bacteria was observed in blotter test. Seed treatment with Hexathir or Captan @ 4 g per kilogram of seeds reduced incidence of spermoplane microflora.

Seed processing and pretreatments

The fleshy covering of the fruits is to be removed before sowing to prevent decay of seeds due to fungal attack. In the case of seeds with their cotyledons exposed

and turned green (collected from the field), they can be sown directly without any processing or pre-treatments. During the present study, fruits as such,

Table 4.2.2. Spermoplane microorganisms detected on the seeds of *D. malabaricum* by blotter method and their relative per cent incidence (RPI)

Sl. No.	Microorganisms	RPI	
		NSS	SS
1	<i>Alternaria</i> sp.	1.00	
2	<i>Aspergillus</i> spp.	12.00	3.00
3	<i>A. flavus</i>	3.00	1.00
4	<i>A. niger</i>	14.00	12.00
5	<i>Chaetomium</i> sp.	2.00	
6	<i>Curvularia</i> sp.		1.00
7	<i>Fusarium</i> spp.	16.00	7.00
8	<i>Penicillium</i> spp.	12.00	2.00
9	<i>Thielaviopsis</i> sp.		
10	<i>Trichoderma</i> sp.	22.00	4.00
11	<i>Verticillium</i> sp.	2.00	
12	Sterile mycelium	3.00	1.00
13	Bacteria	6.00	
14	Actinomycetes	18.00	9.00

NSS: Non-surface sterilized; SS: Surface sterilized

seeds without any pre-treatment, seeds soaked in water for 24 hours and seeds stored in gunny bags were tried for germination in the nursery bed and one set of seeds were dibbled in polypots filled with potting mixture and the details recorded are given in Table 4.2.3.

Nursery technique

Seed sowing

Seeds can be sown in nursery beds or dibbled in polythene bags. In nursery beds, drilled lines, 20 cm apart, may be taken and seeds sown 5 cm apart, in

order to facilitate pricking. About 41 kg of fruits on processing will give about 35 kg of seeds, which is sufficient for a standard nursery bed. In polythene bags of 23 cm x 17 cm size, filled with potting mixture, one or two seeds each can be sown with a thin layer of soil above, covering the sown seeds. The sown seeds are to be watered regularly. Rai (1999) suggested to spread a thin layer of litter above the sown seeds in polypots.

Table 4.2.3. Details of processing and germination of the seeds of *D. malabaricum*

Seed sample	No. of seeds sown/bed	Duration of treatment	Quantity required/bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Fruits sown as such	492	Nil	41 kg	Nil	Nil	Nil	Nil
Seeds sown as such	490	Nil	3.92 kg	18 days	30 days	98	20
Seeds soaked in water	510	24 hours	4.04 kg	15 days	25 days	89	18
Seeds sown in polybags	500	Nil	4 kg	20	35	85	17.3
Seeds stored in gunny bags	500	15 days	3.90 kg	25	30	10	2

Seed germination

Within about 18 days of sowing, germination will start and was completed by about 30 days, in both polypots and also in the nursery beds. According to Rai (1999), *D. malabaricum* seeds germinate within 7 days and the germination will be completed by about 15-20 days. Seeds stored in gunny bags for 10-15 days also germinated within the same period, even though the germination percentage is very low (2%), whereas fresh seeds sown, registered a germination rate of 20 per cent in the present trial (Table 4.2.3). Only those seeds with green cotyledons germinated in both the nursery bed and the polypots and others perished, which brought down the germination rate to about 20 per cent.

Overhead shade is necessary for the seedlings retained in the nursery and regular watering was also done.

Nursery pests and control

Mild attacks of a leaf webbing caterpillar (Pyrilidae), acridid grasshoppers and mealy bugs were noticed in the nursery. No control measures were undertaken, as the incidence of these insects was sporadic and not causing major injury to the seedlings.

Nursery diseases and control

In seedbed nurseries of *D. malabaricum*, collar rot disease was recorded affecting 20 to 30-day-old seedlings. Even though, the disease incidence was not severe, the disease occurred in small patches affecting 5 to 10 seedlings. The first symptom of the disease was the appearance of water-soaked lesions on the collar region of seedlings. These lesions develop into pale brown necrotic area and the affected tissues become rotten, which results in the collapse of the seedlings. Sporulation of the causal fungus appears as white powdery structures on the rotten area. Isolations from the diseased tissues consistently yielded *Fusarium moniliforme* and the pathogenicity test using the seedlings confirmed *F. moniliforme* as the causal agent of the collar rot. Fungicides screened against the pathogen employing poison food technique showed Dithane M45 (0.1% a.i) as the most effective one. In the nursery, application of Dithane M45 (0.1% a.i) controlled the infection.



Fig. 4.2.5. Shot-hole disease in *D. malabaricum* seedlings in the nursery

Fusarium spp. cause various seedling diseases, viz., seed rot, seedling wilt, collar rot, foliage infection, etc. In the blotter test, seed rot caused by *Fusarium* sp. was recorded and hence, the disease may be seed-borne.

Shot-hole caused by *Colletotrichum gloeosporioides* (Penz.) Sacc. was yet another disease recorded in nursery affecting *D. malabaricum* seedlings (Fig. 4.2.5). The disease was recorded in both seedbed and container seedlings. The

symptoms developed on the leaves of seedlings as dark green circular to irregular areas lined with a pale yellowish green margin. The colour of the affected patches changes into pale yellow and greyish brown. The necrotic patch becomes detached from the leaf forming a shot-hole in the leaf lamina. Pathogenicity of *C. gloeosporioides* was proved in artificial inoculation test. The shot-hole formation is the host plant's resistance reaction (hypersensitive reaction) against the invading pathogen. Similar disease has been recorded in many forestry species in Kerala (Sharma *et al.*, 1985). The disease in the nursery of *D. malabaricum* was controlled by foliar application of Bavistin (0.05% a.i.) at weekly interval.

Bacterial leaf spot caused by *Xanthomonas* sp. was another foliage infection recorded in the nursery of *D. malabaricum* (Fig. 4.2.6). The disease appeared as water-soaked circular to irregular lesions, which later become coalesced to form large, irregular necrotic patches. The affected areas become thin, shiny and sticky to touch. These diseased patches often become detached from the leaf or the whole leaf becomes defoliated in due course. In artificial inoculation experiment, the pathogenicity of the bacterium was proved. As the disease incidence in nursery was very low, no control measure was adopted. However, the bacterial foliage infection, if severe, can be controlled by foliar application of Plantamycin (0.01% a.i.). Even though, fungi are responsible for the major diseases in forest nurseries, bacterial diseases are not uncommon. Earlier, bacterial leaf spot caused by *Pseudomonas* sp. and *Xanthomonas* sp. have been recorded in various forestry species from Kerala (Sharma *et al.*, 1985).



Fig. 4.2.6. Bacterial infection of *D. malabaricum* in poylpotted seedling

Pricking and maintenance of seedlings

The seedlings in the nursery beds attain an average height of 15.5 cm within four months, and by that time, they are ready for pricking and potting (Fig. 4.2.7). The potted seedlings can be maintained in the nursery for about 10

months before they are field planted during the rainy season (Fig. 4.2.8). Troup (1921) and Rai (1999) used 10 to 12-month-old seedlings for plantation trial, which by that time, attain an average height of 30 cm. It is better to keep the seedlings in open sun for 10-20 days with regular watering, before field planting to harden them.



Fig. 4.2.7. Potted seedling of *D. malabaricum*



Fig. 4.2.8. Nursery seedlings of *D. malabaricum*

Root trainer technology

Ripened fruits of *D. malabaricum* are available only during June-July. Therefore, seed samples were not available for the trial with root-trainers during April-May, 2002. However, seeds dibbled in poly-pots filled with potting mixture gave almost equal germination per cent as in the case of seed-beds and therefore, dibbling seeds in root-trainers of sufficient cell-size, filled with mixed weed or coir pith compost, can probably give similar or improved germination percentage.

Vegetative propagation

Three concentrations of IBA, viz. 3000 ppm, 4000 ppm and 5000 ppm, were used to root cuttings of juvenile stems, branchlets and sprouts from mature



Fig. 4.2.9. Treated cuttings of *D. malabaricum*

branches. The treated samples were planted in vermiculite filled root trainers and kept in mist chamber. For each of the concentration of IBA tried, 24 samples were used for each type of the propagule tried (Fig. 4.2.9). Branchlets (hormone treated and planted) failed to root and for the other two samples (juvenile stems and sprouts),

the maximum rooting was 12.45 per cent for samples treated with 3000 ppm IBA.

Plantation method

Out-planting of seedlings

Being a species of the evergreen habitat, the plantation site selected was also in an evergreen forest area at Thottapura in Kolathirumedu range of Vazhachal Forest Division, along with the plantation trial of *Calophyllum elatum*. The cleared area was aligned and staked at 2 m x 2 m spacing and pits of 30 cm x 30 cm x 30 cm were taken. Poly-potted seedlings (after removal of the containers) were planted during the South-West monsoon period of June, 2001. A total of 540 seedlings were planted (Fig. 4.2.10) in the field.



Fig. 4.2.10. Out-planted seedling of *D. malabaricum*

Survival of seedlings

Out of the 540 seedlings field-planted, 97 per cent survived after one month and the casualties were replaced. However, the survival percentage slowly decreased and during the twelfth month (June, 2002), only 61 per cent (Table 4.2.3) of the seedlings survived the drought during the monsoon season.

Table 4.2.3. Details of survival and growth of out-planted seedlings

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	523	17	97	31.6
6 months	487	53	90.4	33.2
9 months	365	175	67.5	33.5
12 months	329	211	61	34.3

Plantation pests and control

Only mild feeding by caterpillars, grasshoppers and mealy bugs were noticed in the out-planted seedlings warranting no control measures.

Plantation diseases and control

In the trial plantation raised at Thottapura in Vazhachal Division, minor foliage infection caused by *Colletotrichum gloeosporioides* (*Glomerella cingulata*) was recorded. Besides forming shot-holes, the infection also caused necrosis of margins of the leaf blade. The affected leaf margin in turn leads to inward curling of the leaves. Disease specimens collected periodically from the plantation also yielded *Alternaria alternata* and *Pestalotiopsis* sp. associated with leaf tip blight, and *Phomopsis* sp. associated with leaf-spot. The *Phomopsis* leaf-spot ranges from small dark brown pin-head lesion to greyish brown irregular lesions (3-6.5 mm in diameter).

Sooty mould was quite common in the trial plantation and infection of medium severity was observed in certain patches. The disease occurred in the form of superficial black patches on both the leaf surfaces, but more on the upper surface. The infection caused no other deformity, except reducing the photosynthetic efficiency of the plants. The fungus, *Meliola* sp. was identified as the causal agent of the sooty mould disease. Sooty mould is common in tropical forests, which forms a network of dark brown to black mycelia and affects a wide variety of natural and cultivated plants. In general, the disease causes reduction in the photosynthetic area of the plants and adversely affects the photosynthetic efficiency of the plants. In certain cases, premature defoliation due to severe infection has also been recorded. *Meliola* is the common genus which causes sooty mould, and a large number of tree species are known to be affected by the fungus in Kerala (Sharma *et al.*, 1985). Since none of the diseases recorded seriously affected *D. malabaricum* seedlings in the trial plantation, no control measure was taken.

Growth of seedlings

Within a period of twelve months, an average height of 34.3 cm was recorded for the field-planted seedlings.

Conclusions and recommendations

Ripened fruits devoid of the attack of *Dauccs* flies are to be collected from natural stands. Without any pre-treatment, almost 20 per cent of the seeds

germinated within 15 days and for treated seed samples, the germination percentage was still low. Even though, there are a few pest and disease problems in the nursery and plantation trial of *D. malabaricum*, either they are not serious or can be managed easily. The out-planted seedlings attained an average height of 34.3 cm within 12 months. The vegetative propagation method tried for the species using juvenile stem cuttings is not found very successful as only about 12.5 per cent of the treated samples rooted. Root trainer technology could not be tried for the species due to lack of availability of seeds. However, it may be possible to use root trainers with sufficient cell-size for the germination of seeds. Plantation of the species can be raised only in evergreen forest areas with dense shade (as drought can seriously affect the seedlings), in order to ensure better survival and growth of field-planted seedlings.

4.3. GARCINIA GUMMI-GUTTA

(Guttiferae)

Kodam-puli

Botanical nomenclature

Garcinia gummi-gutta (L.) Robson, Brittonia 20: 103. 1968. *Cambogia gummi-gutta* L., Gen. Pl. ed. 5: 522. 1754. *Garcinia cambogia* (Gaertn.) Desr. in Lamk., Encyl. Meth. Bot. 3: 701. 1792.

Local names

Kodam-puli, Meen-puli, Pinenga, Pinaru, Koda-puli, Gorakka-puli, Kedaka-puli.

Species description

Trees, up to 25 m high with a rounded, dense canopy; bark smooth, black, exuding a yellow gum; branchlets horizontal and often slightly drooping, glabrous. Leaves simple, oblong or elliptic, rarely lanceolate, entire, glabrous, glossy, dark green with faint lateral nerves, acute or obtusely short acuminate at apex, narrowed into the petioles at base. Flowers white, pale white or greenish white, polygamous; male flowers in umbellate clusters, fascicled in the axils with 4, obovate, unequal sepals, 4 obovate or oblong, concave petals and 12-20, or more stamens, inserted on the prominent receptacles with bilocular anthers, basifixed and dehiscing vertically; female flowers solitary with numerous staminoides and ovoid or subglobose ovary and stigma rays spreading and free near to the base. Berries light yellow, fleshy, 6-8 grooved, depressed globose, with 6-8 seeds covered by succulent, white aril, pale brown, veined (Fig. 4.3.1).



Fig. 4.3.1. A tree of *G. gummi-gutta*

Distribution

Moist deciduous forests and other areas in the midlands and hilly uplands, especially in the southern part of Kerala, often cultivated in homesteads; endemic to peninsular India from Karnataka southwards.

Phenology

Flowering from January onwards and fruits ripen during May to September.

Timber and other products and uses

Log quality

The tree is grown in Kerala, mainly for its fruits, even though the timber is suitable for making match boxes, splints and posts. The grey, close-textured wood is moderately heavy (640-800 kg/m³), but is not durable (Nazma *et al.*, 1981). However, heart-wood of old trees is hard and durable. The logs are straight, up to 10 m long and about 1 m girth; branches are also straight and up to 5 m long.

Other products and uses

The fruits are acidic and are eaten raw or pickled. The fleshy rind, fresh or after drying and smoking, is used as a condiment for flavoring curries and as a substitute for tamarind, mango and lime in various preparations. It is also used for polishing gold and silver ornaments and as a substitute for formic acid and acetic acid for coagulation of rubber latex. The bark yield Gummi-gutt or Camboge, which is mainly used as a pigment in miniature paintings and water colours, besides its medicinal value as a purgative, hydragogue and emetic. The bark-gum also makes a good varnish. The seed is a good source of edible fat.

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection

The *G. gummi-gutta* trees bear ripened fruits mostly during the rainy season of June-July. Even though they fall on ripening, in order to procure sufficient quantity of seeds, the branches of trees bearing yellow, ripened fruits can be shaken or beaten and the required number of fruits collected (Fig. 4.3.2). The fruits fallen on the ground after ripening deteriorate within a month, leaving behind the seeds. The



Fig. 4.3.2. Fruits of *G. gummi-gutta*

rind and the pulpy parts of fruits are to be removed and the succulent white aril of seeds thoroughly washed in water to get clean seeds, before they are sun-dried and stored. Care should also be taken to discard flat and thin seeds, as they may not germinate. In the present experiment, seed samples with aril were also used in the nursery trial to note the difference in germination rate, apart from seeds without aril and those samples stored for five months.

Seed characteristics

On an average, 6-10 fruits weigh one kilogram and each of them will contain 5-8 seeds. On an average, 75 kg of fresh fruits contain one kilogram of seeds, which usually contain 590-600 numbers. The fruits are of the average size of 5.8 cm x 6.5 cm, almost globose, ridged and light yellow in colour. After removing the rind and also the white succulent aril, the brown, ovoid seeds (Fig. 4.3.3) of an average size 3.3 cm x 1.5 cm can be used for germination (Table 4.3.1).



Fig. 4.3.3. Seeds of *G. gummi-gutta*, with and without aril

Table 4.3.1. Fruit and seed characteristics of *G. gummi-gutta*

	Colour	Size (cm)	Shape	No. per kg
Fruit	Light yellow	5.8 x 6.5	Depressed globose	6-10
Seed	Pale brown	3.3 x 1.5	Ovoid	590-600

Seed storage

The dried seeds have to be sown in the nursery, as early as possible, and storage will lead to infestation of pests and mould. Rai (1999) had suggested to mix the fresh, cleaned and dried seeds with ash, farmyard manure and red earth and pack inside paddy straw to retain their viability for about six months.

Seed pests and control

No instance of pest damage was noticed in both fresh and stored seeds of *G. gummi-gutta*.

Seed diseases and control

Only few fungi like species of *Cladosporium*, *Trichoderma*, *Geniculosporium*, *Scolecobasidium* and sterile mycelium were recorded on the seeds of *G. gummi-gutta* in blotter tests. Relative per cent incidence (RPI) of these fungi was very low and ranged from one to six. *Cladosporium* species recorded the highest incidence. As the incidences of spermatophyte microbes were very low, seed dressing with fungicide was not carried out.

Seed processing and pre-treatments

The rind and pulpy part of fruits were removed and the seeds were thoroughly washed in water. The cleaned seeds were spread out and dried under shade for 4-5 days. Removal of the white succulent aril and seed coat is found to enhance the germination rate, substantially. However, trials were also conducted with processed seed samples like seeds with succulent aril, seeds without succulent aril, seeds without seed coat and those stored for 5 months (Table 4.3.2).

Table 4.3.2. Details of processing and germination of *G. gummi-gutta* seeds

Seed samples	No. of seeds per bed	Quantity sown per bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated within the period	Germination percentage
Seeds sown with succulent aril	912	1.52 kg	150 days	365 days	137	15%
Seeds sown after removing succulent aril	980	1.63 kg	140 days	335 days	441	45%
Seeds sown without seed coat	1100	1.83 kg	10 days	58 days	908	82.5%
Seeds sown after storage of 5 months	210	0.35 kg	10 days	30 days	109	52%
Seeds without seed coat sown in ploybags	590	0.98 kg	45 days	70 days	419	71%

Nursery techniques

Seed sowing

Fresh and dried seeds after removing the seed coat are sown for better germination. They were sown both in the nursery beds and dibbled in potting mixture filled polypots. It is noted that, for a standard nursery bed, about 1.5-2 kg of seeds will be sufficient so that the minimum space will be available for the seedlings to grow and to facilitate pricking. Other samples used in the trial experiment are those with and without aril (sown both in the nursery beds and polypots) and seeds stored for five months. The results obtained are given in Table 4.3.2. When sown in polythene bags, 2 seeds were sown per bag (Fig. 4.3.4) and one of the seedlings was removed later.

Seed germination

In the case of seeds sown without removing the white succulent aril, it took about 5 months to start germination which continued for about a year. The germination percentage was quite low (15%) due to damage or loss of seeds by unnoticed infections within the soil. In the case of seed samples sown after removing succulent aril, 45 per cent germinated and those seeds sown after removal of seed coat registered a maximum of 82.5 per cent germination, and therefore, this method appeared the most ideal one. For samples stored for five months, only 52 per cent germination (Table 4.3.2) was recorded. Rai (1999) noted the germination period of cleaned and dried seeds as 25-60 days and germination rate as 55 per cent.

Other than sowing seeds in nursery beds and dibbling in polypots, Rai (1999) also suggested the following method to raise seedlings from stored seeds.



Fig. 4.3.4. Poly-potted seedlings of *G. gummi-gutta*

The seeds are to be mixed with cowdung or farmyard manure and tightly packed in paddy straw in the form of a bundle. The bundle is then soaked in water to make it wet and then kept in a shallow pit which is slightly deeper than the thickness of the bundle. The pit is covered with 5-6 cm thick layer of soil and regularly watered, once in two days. The seeds are reported to germinate by about 45-50 days.

Otherwise, a pit of 60 cm x 60 cm x 60 cm, lined with paddy straw and a layer of farmyard manure or cow dung, is prepared and the stored seeds are spread in the pit, which is again covered with straw (Rai, 1999). Several layers can be made alternating with seed layer and straw layer and the top of the pit may be covered with a layer of straw and kept pressed with sand bags or stones. Seeds germinated within 30-40 days (Rai, 1999) when they were removed and potted. It is also suggested to spray Carbofuran (60g/1x1m²) in the nursery bed, once in two months, to avoid the infestation by ticks and mites. Also, the practice of spraying Copper Oxychloride (3 g in one litre of water per one square metre of bed) is recommended, which will prevent fungal attack on tender leaves.

Nursery pests and control

Up to 10 per cent damage of nursery seedlings due to a dipteran leaf miner was noticed in the nursery seedlings of *G. gummi-gutta*, which led to crinkling and subsequent withering of leaves (Fig. 4.3.5). Also, mild attack of aphids in a few seedlings, sucking the sap of tender leaves was recorded. Very few instances of root feeding by termites also occur in the seedlings maintained in nursery beds.



Fig. 4.3.5. Crinkling and withering of leaves in *G. gummi-gutta*

Nursery diseases and control

In the seedbed nursery of *G. gummi-gutta*, very low incidence of collar rot caused by *Rhizoctonia solani* Kuhn was observed. The disease affected 10 to 20-day-old seedlings, causing water-soaked longitudinal lesions at collar region, which turn to dark brown in colour and become sunken and necrotic in due course. Timely application of fungicide (Carboxin, 0.1% a.i.) saved the seedlings. Other minor foliage infections recorded in seedbeds and container seedlings include leaf-spot caused by species like *Colletotrichum gloeosporioides*, *Phomopsis* sp., *Curvularia lunata* and *Pestalotiopsis* species. The disease caused by *C. gloeosporioides* is characterized by dark reddish brown colour, measuring 2-3 mm in diameter, with a pale greyish margin. The small spots become coalesced and form large necrotic lesions of 6-8 mm diameter. Withering of tissues in necrotic areas was also noticed, while shot-

hole formation was not observed. *Curvularia lunata* and *Pestalotiopsis* sp. were found associated with necrotic lesions on leaf margins and leaf tips. Small greyish brown spots with concentric rings of pale and dark coloured areas were observed in container seedlings. Isolations from these spots yielded a *Phomopsis* sp. as the causative organism. Even though, the foliage infections in nursery of *G. gummi-gutta* seedlings were of minor significance, application of Dithane M45 (0.1% a.i.) at weekly interval was found effective in protecting the seedlings.

Among more than 425 species of *Garcinia* in the world, 22 species are found in India. Earlier, diseases were recorded from species like *G. indica* Choisy, *G. livingstonei* T. Anders. and *G. mangostana* L. These include leaf rust caused by *Aecidium garciniae* Sund. et Rao, leaf spots caused by *Cercospora dapoliana* Garud, *C. vismicola* Chupp., and *Septoria* sp. in *G. indica* (Patel et al., 1949; Sundaram and Rao, 1957; Seshadri et al., 1972). However, so far no disease has been recorded from *G. gummi-gutta* trees in Kerala.

Pricking and maintenance of seedlings

Seedlings in the nursery bed, by about 3 months, attain an average height of 11.5 cm with 2-4 leaves, when they can be pricked and poly-potted (Fig. 4.3.6). Before out-planting the potted seedlings are to be regularly watered and pots weeded to maintain them for about 4-5 months, when they will attain an average height of 17.5 cm.



Fig. 4.3.6. Poly-potted seedling of *G. gummi-gutta*

Root trainer technology

G. gummi-gutta produce ripe fruits during June-July and therefore seeds were not available to try the root-technology to generate seedlings of the species. However, seeds sown in potting mixture filled polypots gave 71 per cent germination, and therefore, root-trainers with mixed weed or coir pith can also be used to germinate seeds of *Garcinia gummi-gutta* with probably the same or more germination rate.

Vegetative propagation

Juvenile stem cuttings were tried for rooting. Three concentrations of IBA were used (3000 ppm, 4000 ppm and 5000 ppm) for the experiment. For each concentration of the rooting hormone used, 24 samples were tried in vermiculite-filled root trainers (Fig. 4.3.7). The maximum rooted samples (54%) were in 4000 ppm IBA treated samples after one month.



Fig. 4.3.7. IBA treated cuttings of *G. gummi-gutta*

Plantation methods

Out-planting of seedlings

The poly-potted seedlings, maintained in the nursery, were field-planted during the rainy season, in August 2001. Being a species of the midlands and moist deciduous forests, the plantation trial was conducted in the Campus of Field Research Centre of KFRI at Velupadam. The area for planting was cleared of weeds and other secondary growth, including teak coppice growth, aligned and staked at 2 x 2 m spacing and pits of 30 cm x 30 cm x 30 cm dimension were taken. A total of 560 potted seedlings were planted after removing the polythene covers, without disturbing the soil around the roots of the seedlings (Fig. 4.3.8).



Fig. 4.3.8. An out-planted seedling of *G. gummi-gutta*

Survival of out-planted seedlings

The survival and growth of out-planted seedlings were monitored at monthly interval. At the end of three months, almost 65 per cent of the out-planted seedlings survived (Table 4.3.3) and the survival percentage came down to 50.5 per cent after six months. The casualty was mainly due to heavy grazing by deer, and the damaged seedlings were replaced twice, ie. after three months and six months. At the end of ten months the survival percentage was reduced to about 32 per cent due to drought and also casualties by grazing of wild animals.

Table 4.3.3. Survival and growth data of outplanted seedlings of *G. gummi-gutta*

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	283	267	65	18.1
6 months	330	220	50.5	19.5
10 months	214	336	32	21.4

Plantation pests and control

There is no potential pest recorded in the plantation trial of *G. gummi-gutta*.

Plantation diseases and control

In out-planted seedlings no major disease was recorded except for minor leaf-spots caused by *Colletotrichum gloeosporioides*.

Growth of seedlings

The 5-month-old nursery seedlings were field-planted. After ten months of planting, the seedlings attained an average height of 21.4 cm (Table 4.3.3).

Conclusions and recommendations

The seeds of *G. gummi-gutta* are available in plenty from homesteads and forest areas of the State. The seeds, after removal of aril and seed coat, can be sown in nursery beds to get almost 82.5 per cent germination. The leaves of nursery seedlings are slightly affected by pests like leaf-minor and aphids and sometimes the roots of seedlings are eaten away by termites. However, due to the high germination rate of seeds, such problems will not affect large scale production of seedlings, and if required, they can also be controlled by the application of pesticides. The vegetative propagation method tried for the species using juvenile stem cuttings gave 54 per cent success in 4000 ppm IBA tried. The species can be easily grown on a large scale, both in homesteads and moist deciduous forest areas of the State, even though grazing by wild animals like deer and drought are important factors, adversely affecting the survival and growth of field-planted seedlings.

4.4. *GMELINA ARBOREA*

(Verbenaceae)

Kumbil

Botanical nomenclature

Gmelina arborea Roxb., Pl. Corom. t. 246. 1815. *Premna arborea* Roth, Nov. Pl. Sp. 287. 1821. *Gmelina rheedii* Hook., Bot. Mag. t. 4395. 1885.

Local name(s)

Kumbil.

Species description

Deciduous trees, 10-15 m high; bark smooth, whitish-grey or pale white. Leaves simple, opposite, ovate-deltoid, entire, coriaceous, densely tomentose below, 3-nerved from the base, acuminate at apex, cordate at base. Inflorescence axillary or terminal panicles. Flowers brownish yellow; calyx cup-shaped, 5-toothed, teeth very small or obsolete, tomentose externally; corolla tubular, 2-lipped, ventricose, tomentose externally; stamens 4, included in the corolla tube. Drupes yellow, ellipsoid, fleshy, usually 2 or rarely one seeded; seeds ellipsoid, about 1.2 cm x 0.8 cm, brown coloured (Fig. 4.4.1).



Fig. 4.4.1. A tree of *G. arborea*

Distribution

Moist deciduous and semievergreen forests of Kerala, often planted as an avenue tree; Sri Lanka, Philippines.

Phenology

Flowers after defoliation during March to April and fruits ripen during May and June.

Timber, wood characteristics and uses

Log quality

Logs about 25 m length and 50 cm in diameter, are quite common for the tree.

Wood properties and uses

Sapwood and heartwood are not distinct. The wood is creamy white to pale yellowish grey or buff, turning to yellowish brown on exposure. It is soft to moderately hard and light to moderately heavy, ie. 415-610 kg/m³ (Nazma *et al.*, 1981). The wood can be air-seasoned and kiln-seasoned, easily sawn, work well to smooth finish and takes good polish. The wood is also usually quite uniform in colour, and except for occasional roe-mottling, imparting a silvery sheen colour. After seasoning, the wood is very steady and therefore, it is considered as a first class workshop wood, quite durable also. The wood is mainly used in construction, ship building as class one plywood for various purposes. Furniture, tool handles, rehabilitation aids, textile mill accessories, sports items, musical instrument parts etc are also made from the wood.

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection

Fruits which ripen and fall during May-June can be gathered from the ground or by plucking from standing trees. The fruits which are yellow on ripening will change into brown colour and within two weeks after dispersal they will be



Fig. 4.4.2. Fruits and seeds of *G. arborea*

black in colour. During seed collection, care should be taken to gather yellowish brown fruits to ensure better quality and germinability (Fig. 4.4.2). The fruits are to be depulped to get the seeds for sowing and depulping can be done by heaping in shade

for 4-5 days or burying and washing them in water. The cleaned seeds can be dried in shade for 3-4 days and then stored or sown in the nursery for germination. Seeds from the spittings of deer were collected from Nenmara and Nilambur forests for germination trial.

Seed characteristics

Gmelina fruits are of the average size of 2.1 cm x 1.4 cm and about 120-128 of them weigh one kilogram. Seeds obtained after removal of the pulpy portion of fruits are of the average size 1.2 cm x 0.8 cm, and about 980 to 1060 of them

Table 4.4.1. Fruit and seed characteristics of *Gmelina arborea*

	Colour	Shape	Size (cm)	No. per kg
Fruits	Yellow	Ellipsoid	2.1 x 1.4	120-128
Seeds	Brown	Ellipsoid	1.2 x 0.8	980-1060

will weigh one kilogram (Table 4.4.1). However, Kumar and Bhanja (1992) recorded seed samples of lighter weight constituting 1129-2500 numbers per kilogram and Parkash *et al.* (1991) reported on samples which contain up to 2600 seeds per kilogram.

Seed storage

Only dried seeds can be stored for long and there are varying reports on the storage capacity of *G. arborea* seeds as detailed by Greaves (1979), which depends mainly on different storage conditions. There are also reports that seeds stored for 2 years lose their germination capacity by about 10 per cent (Greaves, 1979). Both gunny bags and sealed drums can be used for storing the dried seeds, which can also be stored in dry and well-ventilated rooms with little reduction in germination percentage.

Seed pests and control

No pests, both in fruits and stored conditions, are found to affect the seeds of *G. arborea*.

Seed diseases and control

Rich growth of spermioplane microflora was recorded on seeds of *G. arborea*, which include 13 fungi belonging to 10 genera and an actinomycete (Table 4.4.2). Among the storage moulds recorded, *Trichoderma viride* was the most predominant one. Both the field fungi, *Colletotrichum gloeosporioides* and *Cylindrocladium parvum* recorded on seeds were found associated mostly with

poorly filled seeds. All the *Colletotrichum* affected seeds became rotten and the emerging radicle was also found infected. *C. gloeosporioides* seems to be a seed-borne fungus in *G. arborea*. Heavy sporulation of *Cylindrocladium parvum* was recorded on the affected seeds.

Table 4.4.2. Spermiophane micro-organisms detected on seeds of *G. arborea* by blotter method and their relative per cent incidence (RPI)

Sl. No.	Micro-organisms	No. of seeds * affected	RPI
1	<i>Aspergillus</i> spp.	3	1.39
2	<i>A. niger</i>	14	6.51
3	<i>A. nidulans</i>	1	0.46
4	<i>Bispora</i> sp.	2	0.93
5	<i>Chlamydomyces palmarum</i>	12	5.58
6	<i>Cladosporium</i> sp.	2	0.93
7	<i>Colletotrichum gloeosporioides</i>	5	2.32
8	<i>Cylindrocladium parvum</i>	9	4.18
9	<i>Mucor</i> sp.	9	4.18
10	<i>Penicillium</i> sp.	13	6.04
11	<i>Periconia</i> sp.	4	1.86
12	<i>Trichoderma viride</i>	32	14.88
13	<i>Trichoderma</i> sp.	2	0.93
14	Actinomycetes	10	4.65

* Conc. Sulphuric acid treated pooled sample

Seed dressing with Captan @ 4g/kg of seeds was found effective in reducing the storage moulds of *G. arborea*.

Seed processing and pre-treatments

No pretreatment was given for the seeds in the present study as it is already known that treatments like soaking in boiling water (100 °C), hot water (60-70

°C), etc have no impact on the germination rate. However, seeds collected from the droppings of deer and those stored for one year were also tried in the experiment to record germination rates (Table 4.3.3) and the germination started quite early for the seeds from droppings.

Table 4.4.3. Details of processing and germination of the seeds of *G. arborea*

Seed sample	No. of seeds sown/bed	Duration of treatment	Quantity sown/bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Fruits dried and sown as such	282	Nil	2.35 kg	Nil	Nil	Nil	Failed to germinate
Seeds dried and sown as such	980	Sun dried for 2 weeks	1 kg	21 days	45 days	787	80.3
Seeds from droppings of deer	1100	Nil	1.1 kg	10 days	60 days	1034	94
Seeds stored for one year	550	Nil	0.56 kg	35 days	50 days	113	20.6

Nursery techniques

Seed sowing

Dried seeds were sown in nursery beds soon after collection, without any pretreatment. For sowing, furrows were made 10 cm apart and seeds were dibbled at a spacing of 10 cm to facilitate pricking. About one kilogram of seeds is sufficient for a standard nursery bed. The seeds sown in the shaded nursery were covered with a thin layer of soil-sand mixture. Fruits as such and seeds from the droppings of deer and cattle were also tried in the experiment to note the difference in germination rate.



Fig. 4.4.3. Nursery of *G. arborea*

Seed germination

Seeds sown without any pre-treatment started to germinate within 21 days and germination was completed within 45 days. In the case of seeds collected from

the droppings of deer, the germination started early (Table 4.4.3) and the percentage of germination was also quite high (94%), whereas only 20.6 per cent of the seeds stored for one year germinated. Germination percentage recorded was almost 80 per cent for the untreated seeds, whereas the dried fruits failed to germinate (Table 4.3.3). Two or three seedlings sometimes arise from a single stone (seed).

Nursery pests and control

The larvae of *Calopepla leayana* Lat. (Coleoptera: Chrysomelidae) were found feeding on the leaves of seedlings in the nursery, destroying about 10 per cent



Fig. 4.4.4. Epiplemid attack on leaves of *G. arborea*

of them. Moderate to heavy attack by an epiplemid caterpillar *Epiplema fulvilina* Wlk. (Lepidoptera: Epiplemidae) was also noticed in the nursery seedlings. Attack by this insect caused damage to the leaf tissue leaving characteristic marks of injury (Fig. 4.4.4). It was controlled by the application of a 3 per cent solution of Econeem. Minor attack of leaf miners,

aphids and jassids were also seen on the leaves of the seedlings of *G. arborea*.

So far, 34 species of insects have been reported from *Gmelina arborea* in India. Of them, four species have been recorded as serious pests of the tree. This included the leaf caterpillar *Epiplema fulvilina* and the Chrysomelid *Calopepla leayana* recorded in the study. Two other species namely the tingitid. *Tingis beelsoni* Drake causing defoliation of saplings and the scolytid borer *Xyleborus fornicatus* Eichh. causing shoot die back are known to be potential pests of *G. arborea* (Nair *et al.*, 1988). The former can be controlled by the application of 0.03 per cent solution of Rogor (Dimethoate).



Fig. 4.4.5. Seedling blight of *G. arborea*

Nursery diseases and control

G. arborea seedlings raised in seedbed nursery suffered from a few major diseases. Collar rot and seedling blight caused by *Sclerotium rolfsii* was the major disease recorded in seedbeds. The initial symptoms of the disease were the appearance of water-soaked lesions on the seedling stem at the ground level, which spread fast vertically and affected the petiole. The infection also spreads to the foliage forming pale greyish water-soaked irregular lesions. These water-soaked lesions coalesce and form necrotic areas, which often cover the entire leaf, petiole and stem. The affected foliage becomes blighted and the infected seedlings collapse (Fig. 4.4.5). On the affected tissues, fungal mycelia and numerous pale yellow sclerotia develop and further spread of the infection was noticed through the fast spreading mycelial strands from infected tissues to the healthy leaves. The disease was controlled by the application of Bavistin (0.01% a.i.) at weekly interval and by reducing the water regime of the nursery. As high seedling density and high soil moisture may facilitate manifestation and spread of the disease, it is recommended to avoid the same in seedbed nursery.

Leaf spots caused by *Colletotrichum gloeosporioides*, *Corynespora cassiicola* (Berk. et M.A. Curtis) Wei, *Pseudocercospora ranjita* (Chaudhury) Deighton and *Rhizoctonia solani*, and seedling stem infection caused by *Phoma glomerata* and



Fig. 4.4.6. Leaf spot in seedlings of *G. arborea*

Fusarium solani are the other diseases recorded in *G. arborea* nursery. The leaf spot appeared as pale green water-soaked angular to irregular lesions, which coalesced and enlarged and formed large necrotic spots. Even though, the early symptoms produced by the leaf spot causing pathogens are almost similar, the *Colletotrichum gloeosporioides* causing spots became yellowish brown (Fig. 4.4.6). Leaf spots caused by *Corynespora cassiicola* appear as dark brownish black in colour with a pale greyish centre portion. Leaf spot caused by *Rhizoctonia solani* occurred as greyish brown irregular lesions with dark brownish black margin. In all the cases, severe infection led to premature defoliation and affected the seedling vigour. *Pseudocercospora* leaf spots can be detected easily from other

infections, as the pathogen sporulated heavily on the brownish black spots and often resemble the sooty mould infection. Under high humidity, black conidial mass of *P. ranjita* occur on both the surface of the affected leaves. All the above seedling diseases recorded in seedbeds and container seedlings were controlled by two consecutive application of Bavistin (0.1% a.i.) at fortnightly interval. Before transporting to the planting site another treatment (Bavistin 0.1% a.i.) was also given to safeguard the seedlings from the diseases.

Most of the diseases affecting the *G. arborea* seedlings reported here have been recorded earlier from the State (Sharma *et al.*, 1985), except *Sclerotium rolfsii*, *R. solani*, and *P. glomerata*. Though, *S. rolfsii* was recorded earlier on *G. arborea* from elsewhere causing seedling diseases, the blight disease reported herein is a new record on *G. arborea* from the State. Earlier, *Phoma nebulosa* (Pers. ex S.F. Gray) Berk. has been reported as causing seedling stem infection. *P. glomerata* is a new pathogen record on *G. arborea*. The diseases recorded on *G. arborea* include leaf spots caused by *Cercospora ranjita* Chaudhury, *Colletotrichum capsici* (Syd.) Butler et Bisby and *Helicospira microflora* Seshadri.



Fig. 4.4.7. A poly-potted seedling of *G. arborea*

Pricking and maintenance of seedlings

The seedlings grow fairly fast and can be pricked and poly-potted within 30 days. In the nursery, the seedlings can be maintained for 6-7 months with regular watering and shade, till they are ready to field plant (Fig. 4.4.7). By that time, the potted seedlings will attain an average height of 30 cm.



Fig. 4.4.8. Germination of *G. arborea* seeds in root trainers

Root trainer technology

Fresh fruits collected from natural forests were depulped, dried and dibbled in root trainers filled with mixed weed compost and coir pith compost as two different media. After seven days of sowing, germination started which was almost over

by about 30 days (Fig. 4.4.8). Germination percentage was 88 in both the media which is better than the seed-bed method.

Vegetative propagation

Juvenile stem cuttings were tried for rooting. Three concentrations of IBA were used (3000 ppm, 4000 ppm and 5000 ppm) for the experiment. Twenty-four samples were tried for each of the IBA concentration. The cuttings after treatments were planted in vermiculite filled root trainers (Fig. 4.4.9). After one month, 100 per cent rooting was observed for the cuttings treated with all the three IBA concentrations.



Fig. 4.4.9. IBA treated cuttings of *G. arborea*

Plantation method

Out-planting of seedlings

The seedlings were field-planted during the South-West monsoon period. Being



Fig. 4.4.10. Out planted - seedling of *G. arborea*

a species of the moist deciduous forests, the plantation trial was conducted in the Campus of the Field Research Centre of the Institute at Veluppadam (Fig. 4.4.10). In the aligned, staked and pitted area at a spacing of 2 m x 2 m, 562 seedlings were planted in pits of 30 cm x 30 cm x 30 cm size. The planted area was protected from outside interferences, including grazing by domestic animals.

Survival of seedlings

Almost 91 per cent of the field-planted seedlings survived during three months of planting and the survival percentage was reduced to 86 per cent after a period of nine months. This was mainly due to heavy grazing of the seedlings by wild animals like deer, even though most of the grazed seedlings recouped with reduction in height growth as compared to ungrazed seedlings.

Plantation pests

Earlier, Mathew (1986) recorded various insect species associated with the forest plantations of *G. arborea* in Kerala and Jamaluddin, *et al.* (1988) also noted quite a few pest species in the tree in Madhya Pradesh. The tingitid bug *Tingis beelsoni* the scolytid borer *Xyleborus fornicatus*, the beetle *Calopepla* species are potential pests of the tree in plantations.

Plantation diseases and control

Observations from the planted out seedlings could be recorded only up to a period of nine months. No major disease was recorded, except leaf spots of minor significance caused by *Colletotrichum gloeosporioides* and *Pseudocercospora ranjita*. Though, these two diseases which occurred in nursery were controlled by application of fungicides, no control measures were attempted in plantations because of their low significance. Earlier, in plantations, a few diseases including die-back, stem canker and stem decay were recorded from the State (Sharma *et al.*, 1985). Also, Sankaran *et al.* (1987) recorded stem canker in *G. arborea* trees, caused by *Phomopsis gmelinae*, in Kerala. Among these, die-back caused by *Griphosphaeria gmelinae* Sharma, Mohanan *et* Florence and pink disease caused by *Corticium salmonicolor* Berk. *et* Br. are the important ones. Usually, the above disease affects the plants of 2-3 years age.

Table 4.4.4. Survival and growth of out-planted seedlings of *G. arborea*

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	534	28	95	31
6 months	512	50	91.1	32.8
9 months	483	79	86	45.9

Growth of seedlings

Within a period of nine months after planting, the seedlings registered an average height of 45.9 cm (Table 4.4.4). The heavily grazed seedlings, even though recouped, was much less in height when compared to ungrazed seedlings.

Conclusions and recommendations

Germination rate of dry seeds of *G. arborea* was about 80 per cent and of those collected from the droppings of deer was up to 94 per cent. Vegetative propagation using juvenile stem cutting also proved successful for the production of planting stock. Pest and disease problems reported are not of much impact on production of quality seedlings, as was observed during the trial experiment. In field-planted seedlings, grazing by deer is a problem noticed, even though survival rate of out-planted seedlings was quite high. Growth rate of field-planted seedlings was also quite high, attaining an average height of 45.9 cm within nine months.

4.5. GREWIA TILIAEFOLIA

(Tiliaceae)

Chadachi

Botanical nomenclature

Grewia tiliaefolia Vahl, Symb. Bot. 1: 35. 1790. *G. asiatica* L. var. *tiliaefolia* Brandis, Indian Trees 98. 1906. *G. arborea* Roxb. ex Rottler, Ger. Naturf. Berlin Neue Schriften 4: 205. 1803.

Local names

Chadachi, Unnam, Unna.

Species description

Trees, 5-15 m high; bark fissured, pale brown; young shoots densely pubescent. Leaves simple, elliptic, ovate or rarely broadly ovate, serrate, dense, undulate-serrate, crenate, incised or serrulate, pubescent or stellate-hairy, cuneate, acuminate, acute or rarely truncate or obtuse. Inflorescence axillary, umbellate, 3 or more in a cluster; flowers yellow or creamy-white with reddish or deep yellow anthers, fragrant. Drupes globose or rarely 2-4 lobed, green, maturing light grey; seeds with flat, foliaceous or fleshy cotyledons (Fig. 4.5.1).



Fig. 4.5.1. A tree of *G. tiliaefolia*

Distribution

Almost throughout Kerala in dry and moist deciduous forest tracts; India, Sri Lanka, Myanmar, tropical Africa.

Phenology

Flowers mostly from March to June, but maximum during April to July, rarely continuing till the onset of next summer.

Timber, wood characteristics and uses

Log quality

The stem which attains a height of about 20 m and a diameter of about 70 cm, is often poor in form with defects like crook, sweep, adventitious bud clusters,

branch stubs, seam, decay cavities, etc. Due to partial removal of bark, damaged sapwood portion is also quite prevalent on logs in natural stands. Straight saw-logs of 5-6 m in length are usually available from *G. tiliaefolia* trees.

Wood properties and uses

Basic density of the wood of *G. tiliaefolia* vary from 507 kg/m³ to 716.5 kg/m³, locality-wise in Kerala (Nair *et al.*, 1991). However, the average density of wood from breast-height is around 621 kg/m³ (Nazma *et al.*, 1981). Wood grains are rather irregular. Wood density is more in samples from the Southern parts of Kerala (Nair *et al.*, 1991). There is no marked difference in heartwood percentage among specimens from South, Central and Northern parts of the State. Growth rings are also not distinct mainly due to thick-walled latewood fibres and thin-walled early wood fibres.

The wood is moderately hard and heavy with fairly straight grains and medium to coarse texture. The heartwood is reddish-brown and sapwood light greyish-brown. The wood is used for making agricultural implements, construction purposes, railway sleepers, boat and shipbuilding, furniture, poles, ballies, cross arms and fence posts, and so on.

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection

Ripened fruits were collected from Peechi during May-June, either from standing trees or those fallen on the ground on ripening. Seed collection coincided with the onset of monsoon showers. Each fruit generally had two seeds, which were extracted by depulping and washing in water. The seeds were then sun dried.

Seed characteristics

About 6,600 fruits weigh one kilogram before depulping and about 15,000-16,000 seeds constituted one kilogram after removal of the pulp. Sengupta (1937) has reported 19401 seeds/kg for freshly pulped seeds and 5291

seeds/kg for fruits with pulp (Fig. 4.5.2). Fresh fruits are of average size of 0.8 x 0.5 cm and seeds were 0.5 x 0.3 cm in size, flat and grey-coloured (Table 4.5.1).

Seed storage

Even though storage of seeds was not tried in the experiment, according to Dent



(1948) they remain viable for more than four months. Also Rai (1999) suggested the method of storing seeds in gunny bags mixed with BHC to retain their viability.

Fig. 4.5.2. Fruits and seeds of *G. tiliaefolia*

Table 4.5.1. Fruit and seed characteristics of *G. tiliaefolia*

	Colour	Shape	Size (cm)	No. per kg
Fruits	Reddish brown	Subglobose	0.8 x 0.5	6540-6700
Seeds	Grey	Flat	0.5 x 0.3	15,000-16,000

Seed pests and control

Seeds of *G. tiliaefolia* are mostly free from any major pest attack.

Seed diseases and control

Seeds of *G. tiliaefolia* harboured rich microflora, which include 22 fungi, one bacterium and an actinomycete (Table 4.5.2). The spermioplane microflora include common storage moulds and also potential pathogens like species of *Corynespora*, *Cylindrocladium*, *Phoma*, *Phomopsis*, *Myrothecium*, *Fusarium*, *Verticillium*, etc. Interestingly, a *Graphium* sp. was found associated with the discoloured and ill-filled seeds with high RPI (11.78). *Fusarium* sp., *Phoma* sp. and bacteria were found associated with the seed rot. Infection on emerging radicle and plumule caused by *Fusarium*, *Phoma*, *Corynespora* and *Myrothecium* species was also recorded. Fungi like species of *Fusarium*, *Phoma*, *Myrothecium*, etc. which invade the seeds in field during their development may be responsible for the loss of viability and seed rot. Earlier, about nine fungi were

Table 4.5.2. Spermiophyte microorganisms detected on seeds of *G. tiliacifolia* by blotter method and their relative per cent incidence (RPI)

Sl. No.	Microorganisms	No. of seeds affected	RPI
1	<i>Aspergillus</i> sp.	6	2.4
2	<i>A. niger</i>	1	0.35
3	<i>Arthrotrichum oregonense</i>	7	2.50
4	<i>Balanium</i> sp.	2	0.71
5	<i>Cephalosporium</i>	2	0.71
6	<i>Chaetomium</i> sp.	4	1.42
7	<i>Chalaropsis</i> sp.	2	0.71
8	<i>Curvularia lunata</i>	8	2.85
9	<i>Corynespora</i> sp.	2	0.71
10	<i>Cylindrocladium</i> sp.	4	1.42
11	<i>Fusarium</i> sp.	21	7.50
12	<i>Graphium</i> sp.	33	11.78
13	<i>Myrothecium</i> sp.	5	1.78
14	<i>Paecilomyces</i> sp.	7	2.50
15	<i>Penicillium</i> sp.	27	9.64
16	<i>Phoma</i> sp.	8	2.85
17	<i>Phomopsis</i> sp.	3	1.07
18	<i>Stachybotrys kampalensis</i>	9	3.21
19	<i>Torula herbarum</i>	19	6.78
20	<i>Trichoderma</i> sp.	5	1.78
21	<i>Verticillium</i> sp.	3	1.07
22	Sterile mycelium	24	8.57
23	Bacterium	35	12.50
24	Actinomycete	9	3.21

recorded on seeds of *G. tiliaefolia* (Mohamed Ali and Sharma, 1989; Mohanan and Sharma, 1991) with a very high incidence of *Aspergillus* spp. Fungicidal seed dressing with Captan or Carbendazim @ 2 g/kg of seeds was found very effective in checking the spermiplane microflora and maintaining the seed health. Occurrence of rich microflora on seeds could be due to the warm-humid climate prevailing in the State and also inappropriate seed storage conditions. In the absence of an effective seed storage facility, it would be worth to treat the seeds with seed dressing fungicides like Carbendazim or Captan.

Seed processing and pre-treatments

Ripened fruits gathered from the field were depulped, removed of fibrous seed coating and washed thoroughly in water. The seeds thus cleaned were spread out and dried in shade. Pretreatments like soaking in water at room temperature and hot and boiling water were done to note the difference in germination percentage and also the time taken for completing the germination (Table 4.5.3). However, seeds sown without any pretreatment gave the maximum germination.

Nursery techniques

Seed sowing

Freshly collected seeds were sown in plastic trays 50 cm x 50 cm size, filled with vermiculate-soil mixture. About 7 g of seeds are sufficient for one tray. The trial by sowing seeds in nursery beds was also attempted and 10-15 kg of seeds were found to be required for a standard nursery bed of 12 m x 1.2 m. Sunken bed method for sowing seeds is also reported (Rai, 1999) with fairly good germination rate.

Seed germination

Fresh seeds started germination from the 15th day onwards and was completed within 35 days whereas fruit sown as such and seeds pre-soaked in water at room temperature started to germinate by about 55 and 25 days, respectively, which was completed within 150 and 100 days. The seeds presoaked in hot water and boiling water failed to germinate during the trial. For nursery bed sown seeds Nair *et al.* (1991) recorded germination to start on the fifth day after

sowing which was completed within 60 days. In the case of sunken bed method tried by Rai (1999) the germination was completed within 30 days.

Table 4.5.3. Details of processing and germination of *G. tiliaefolia* seeds

Seed sample	No. of seeds sown/bed	Duration of treatment	Quantity required/bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Fruits sown as such	100	Nil	15.3 g	55	150	5	5
Seeds sown as such	100	Sun dried for 2 days	6.6 g	15	35	12	12
Seeds pre-soaked in water	100	24 hours	6.6 g	25	100	8	8
Seeds pre-soaked in hot water	100	1 hour	6.6 g	Nil	Nil	Nil	Nil
Seeds pre-soaked in hot boiling water	100	10 minutes	6.6 g	Nil	Nil	Nil	Nil

With regard to germination rates, freshly collected seeds without any pretreatment registered 12 per cent germination and fresh fruits sown as such gave only 5 per cent germination. In the case of seeds soaked in water at room temperature for 24 hours, 8 per cent was the germination rate whereas, those treated with hot water and boiling water failed to germinate. Rai (1999) could get a germination rate of 60-70 per cent for seeds sown in sunken nursery beds. This is true in the case of seeds sown in nursery beds and kept undisturbed for about 10 months, as observed during the present trial. During the tenth month after sowing, about 70-80 per cent of seeds germinated at a time.

Nursery pests and control

No serious pest problem was noticed in the nursery of *G. tiliaefolia* except for mild leaf webbing by species of *Archips* (Lepidoptera, Tortricidae) and sporadic mild defoliation by species of *Mylloceris* (Coleoptera: Curculionidae). Both these insects are considered to be minor pests in the nursery. Incidence by these

insects were noticed during May to August. Forty species of insects have been reported as pests of this species. Leaf rolling by the pyralid caterpillar *Lygropia orbinusalis* Wlk. and gall formation by an unidentified Psyllid are the two pest problems reported earlier on the seedlings of *G. tiliaefolia* (Nair *et al.*, 1986).

Nursery diseases and control

Leaf spots caused by *Phomopsis* sp., *Pestalotiopsis versicolor* and *Colletotrichum gloeosporioides* were observed in *G. tiliaefolia* seedlings. *C. gloeosporioides* caused small pin head sized pale brown necrotic lesions which later spread to form angular lesions. Most of the spots were noticed in mature leaves only. *P. versicolor* was found associated with leaf margin and tip blotch. Heavy sporulation of the fungus was noticed as black spots on the lower surface of the necrotic lesions. *Phomopsis* sp. was isolated from small pale to dark brown target type spots with a pale centre portion and a dark brown margin. All the above mentioned nursery diseases are only of minor significance. However, *Phomopsis* sp. is a potential pathogen and under favourable nursery conditions, it may cause considerable damage to the seedlings. Fungicidal screening in the laboratory against *Phomopsis* showed that Bavistin (0.1% a.i.) and Dithane M45 (0.2% a.i.) are equally effective in controlling the fungus growth. A prophylactic treatment of Bavistin (0.1% a.i.) was given to the container seedlings, to safeguard against fungal infection, before transporting to the planting site.



Fig. 4.5.3. A polypotted seedling of *G. tiliaefolia*

Pricking and maintenance of seedlings

The seedlings can be pricked out after about 2 months of germination, when they attain an average height of 15 cm with 2-4 leaves. Polythene bags of 23 cm x 17cm were used for potting and maintaining the seedlings up to a period of 2 months in the nursery before out-planting (Fig. 4.5.3).

Root trainer technology

Fresh seeds were collected, depulped, dried and sown in root trainers filled with mixed weed compost and coir pith compost. For each type of compost used, 48 samples were tried. Germination started by about a month with about 12 per cent of seeds producing seedlings within two months.

Vegetative propagation

Juvenile stem cuttings and branchlets were tried for rooting using IBA in three concentrations viz. 3000 ppm, 4000 ppm and 5000 ppm (Fig. 4.5.4). After one month of treatment and planting in vermiculite medium, 40 per cent cuttings gave rooting in samples treated with 5000 ppm IBA, which was the maximum.



Fig. 4.5.4. IBA treated cuttings of *G. tiliacifolia*

Plantation method

Out-planting of seedlings

Being a tree of the moist deciduous forests, the plantation trial was also conducted in a similar area in the Campus of the Field Research Centre of the Institute at Veluppadam in Trichur Forest Division. In the area cleared, aligned and pitted at 2 m x 2 m spacing, the ply-potted seedling were planted in pits of 30 cm x 30 cm x 30 cm size. A total of 510 seedlings were field planted during September 2001 (Fig. 4.5.5).



Fig. 4.5.5. An out-planted seedling of *G. tiliacifolia*

Survival of seedlings

More than 94 per cent of the seedlings survived after three months of field planting. During the ninth month, ie. June, 2002 this was reduced to 66 per cent, probably due to severe drought conditions (Table 4.5.4).

In an earlier plantation trail conducted for the species (Nair *et al.*, 1991), both in pure and mixtures with few other indigenous trees, the highest survival

of 93 per cent was observed in the pure plantations of *G. tiliaefolia*. However, in mixtures, the survival percentage was slightly less (88-90).

Table 4.5. 4. Details of survival and growth of out-planted seedlings of *G. tiliaefolia*

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	480	30	94.2	16
6 months	349	161	68.4	16.4
9 months	337	173	66	25.3

Plantation pests and control

Defoliation, leaf rolling and gall formation are the three important types of damages noticed in the trial plantations of *G. tiliaefolia*. Defoliation by an unidentified caterpillar was the most serious problem both in pure (25%) as well as in mixed plantations (Nair *et al.*, 1991). Leaf rolling by the pyralid *Lygropia orbinusalis* Wlk. was noticed in a small percentage of seedling in the field which was not serious.

Gall formation by an unidentified psyllid was noticed in about 37 per cent of seedlings. The galls were of the pouch type, developed on the leaf stalk as well as on veins of tender foliage leading to distortion and drying up of leaves. The intensity of infestation was moderate. The psyllids can be controlled by the application of Nuvacron 36 EC (Monocrotophos).

The lepidopteran pests particularly the unidentified defoliator is considered as a potential pest of this tree in trial plantations, which can be controlled by application of 0.1% solution of Ekalux 25 EC (Quinalphos).

Plantation diseases and control

In trail plantation of *G. tiliaefolia*, no disease except leaf spots caused by *Colletotrichum* state of *Glomerella cingulata* and *Guignardia* sp., was recorded. *Guignardia* sp. was isolated from dark brown, fast spreading irregular lesions usually found at the base of the leaves. As the disease was of minor significance, no control measure was adopted. So far, only a few fungi

associated with diseases of *G. tiliaefolia* in natural stands have been recorded. *Dasturella grewiae* (Pat. et Har.) Thirum., *Myriangium indicum* Tilak et Kale, *Pericladium tiliaeacearum* Mund. et Thirum, *Phyllosticta grewiae* (Pat. et Har.) Cumm., *Puccinia tiliaefolia* Ramakr. et Sund., *Septoria grewiae* Thirum. are the pathogens recorded on *G. tiliaefolia* (Mundkur, 1952; Ramakrishnan and Sundaram, 1955; Ramakrishnan *et al.*, 1955; Tilak and Kale, 1969; Sukapure and Thirumalachar, 1965; Sohi and Prakash, 1969).

Growth of seedlings

After three months of field planting, the seedlings attained an average height of 16 cm. It may be noted that earlier Nair *et al.*, (1991) had observed that performance of the species is better in mixed plantations with few other indigenous species than in the pure plantings, even though the difference was not statistically significant. Mean annual height increment also followed a similar pattern as height growth (Nair *et al.*, 1991). In the present experiment, the field-planted seedlings attained an average height of 25.3 cm by nine months.

Conclusions and recommendations

G. tiliaefolia trees produce fruits in large quantities during May-June. The seeds germinate by 12 per cent within 60 days after sowing in nursery beds. If the seedbeds can be retained undisturbed, up to 80 per cent seeds germinate during the tenth month after sowing, as observed during the present study. Even though, several species of seed microflora were recorded from the seeds of the species in storage, none of them were potential pathogens and dressing the seeds with Carbendazim or Carboxin can remove all of them. As root trainer method gives only 12 per cent germination, it may not be a convenient method to raise seedlings. However, vegetative propagation which gives 40 per cent success is a better method to produce propagules of the species. The out-planted seedlings perform well in the field with 66 per cent survival after 9 months of planting, covering the summer months also. Moist deciduous forest areas of the State are quite suitable for raising plantation of *G. tiliaefolia*.

4.6. HALDINA CORDIFOLIA

(Rubiaceae)

Manja-kadambu

Botanical nomenclature

Haldina cordifolia (Roxb.) Ridsd., Blumea 24: 361. 1978. *Nauclea cordifolia* Roxb., Corom. Pl. 1: 140. t. 53. 1795. *Adnia cordifolia* Hook.f. ex Brandis, For. Fl. North-West and Central India 263. 1874. *Nauclea sterculiaefolia* A. Rich., Mem. Fam. Rub. 209. 1830.

Local names

Manja-kadambu, Katampa, Veembu, Beembu.

Botanical description

Deciduous trees, 10-20 m high; trunk often buttressed and fluted with flaking bark. Leaves simple, opposite, petiolate, obovate, broadly elliptic, transversely elliptic or rarely transversely broadly ovate, entire or rarely undulate, subcoriaceous, sparsely hairy above, densely pubescent beneath, acuminate, acute or rarely cuspidate at apex, cordate, subcordate or rarely truncate at base. Flowers creamy white or slightly rose-tinged in solitary or paniced heads. Fruiting heads globose with a cluster of capsules; capsules separating in two follicular cocci; seeds with winged testa, tailed above, oblong, ovoid or tricornuate, flattened with two claw-like projections at apex (Fig. 4.6.1).



Fig. 4. 6.1. A tree of *H. cordifolia*

Distribution

Almost throughout Kerala at medium and high elevations. Also disturbed in other parts of India, Sri Lanka, eastwards to South China and Vietnam and southwards to peninsular Thailand.

Phenology

Flowering from April to September and fruits mature during October to January.

Timber, wood characteristics and uses

Log quality

The bole is clear and straight up to 20 m, attaining a diameter up to 1 metre. Older trees are sometimes fluted and buttressed and occasionally forking at lower heights with butt rots.

Wood properties and uses

The wood is uniformly fine-textured and straight grained. The basic density ranges between 503 kg/m³ and 663.5 kg/m³ (Nair *et al.*, 1991) with an average density of 596.5 kg/m³ (Nazma *et al.*, 1981) at breast height (Nair *et al.*, 1991). The wood is used mainly for building purposes. It is also used in making canoes and dugouts, planking of river boats, packing cases, cigar boxes, grain measures, sieve frames, snuff boxes, furniture, yokes, combs, toys, gunstocks, carving and in turnery works. The wood is well reputed for inlay works and can be stained by colour and is suitable for manufacturing bobbins, used in cotton and jute industry. As a minor product, charcoal of calorific value ranging from 6668 to 6813 can also be obtained from the wood of *H. cordifolia* trees, by open or closed kiln methods.

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection

Seeding occurs almost every year and seeds can be collected from standing trees when they are ripe (Fig. 4.6.2). The seeds are minute, and often by



Fig. 4. 6.2. Fruits of *H. cordifolia*

mistake, heads which have already shed their seeds are collected (FRI, 1985). The maturity of seeds has to be carefully observed. When heads become ripe they turn yellowish black in colour and the carpels become flesh red. The heads are to be put in cloth bags and sun dried for a few days. The seeds were then cleaned by winnowing. Though other methods for extraction of seeds are also practiced (FRI, 1985) they are not simple and efficient.

Seed characteristics

The fruits when ripe are brown in colour and globose in shape. They are of an average size of 1.5 cm x 1.7 cm and in one kilogram they will be about 3300 to 3400 fruits. The seeds are minute and ovoid in shape and are brown in colour (Fig. 4.6.3). About 11,000,000 seeds weigh one kilogram (Table 4.6.1) and this almost agrees with the earlier reported figures, ie. 10,765,624 to 11,287,678 seeds per kilogram (Sengupta, 1937).

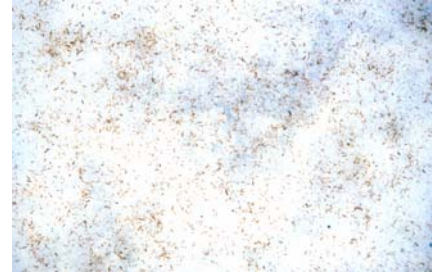


Fig. 4. 6.3. Seeds of *H. cordifolia*

Table 4.6.1. Fruit and seed characteristics of *H. cordifolia*

	Colour	Shape	Size (cm)	No. per kg
Fruits	Brown	Globose	1.5 x 1.7	3300-3400
Seeds	Brown	Ovoid	Minute	11 million

Seed storage

The cleaned and dried seeds can be stored in gunny bags or in sealed tins. It is also reported (FRI, 1985) that seeds stored for a short duration give improved germination. Dent (1948) found that the seeds of *H. cordifolia* can be stored for the next season and not longer and this agrees with the tests conducted at Dehra Dun, recording the storing period as one year.

Seed pests and control

Seeds of the species were almost free from any pest attack, even in stored conditions.

Seed diseases and control

Only a few spermoplane microorganisms were detected on the seeds of *H.cordifolia* in blotter test. Storage fungi like species of *Trichoderma*, *Penicillium* and *Aspergillus* were detected on seeds. Species of *Rhizopus*, *Mucor*, *Curvularia*, *Fusarium*, *Phoma* are the other fungi recorded on the seeds. As the seeds are minute, the fungal mycelium often covered the entire seeds, which adversely affects the seed germination. Earlier, *Aspergillus flavus*, *Rhizopus* sp., *Fusarium*

sp., *Curvularia* sp. and *Phoma* sp. were recorded on *H. cordifolia* seeds (Mathur, 1974; Mohanan and Sharma, 1991; Nair *et al.*, 1991). Carbendazim (@ 3gm/kg seeds) and Carboxin (@ 2g/kg seeds) were the most effective fungicides in controlling the spermoplane microorganisms.

Seed processing and pre-treatments

For the seeds of *H. cordifolia*, no pre-treatment or processing was done, as the seeds were very minute and gave very high germination percentage without treatments. However, experiments with seeds soaked in water at room temperature for 24 hours and those stored for one year were conducted to note the difference in germination percentage.

Nursery techniques

Seed sowing

As the seeds are minute, for practical purposes, they were sown in germination trays of 50 cm x 50 cm size (Fig. 4.6.4), and those filled with vermiculate and

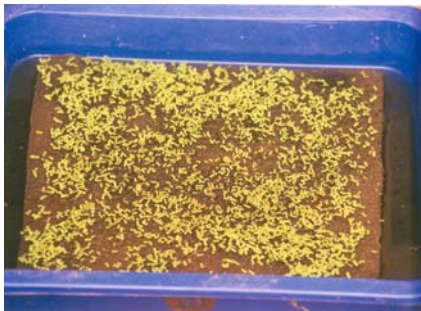


Fig. 4.6.4. Germination of *H. cordifolia* seeds in tray



Fig. 4.6.5. Polypotted seedlings of *H. cordifolia*

also with forest soil free from debris and roots. About 10 g of seeds can be sown in a tray of 50 cm x 50 cm size. Seeds start to germinate by about 5-15 days and germination will be completed within about 30 days. Within one month, the seedling attained a height of 2 cm, when they were pricked and poly-potted (Fig. 4.6.5).

Seed germination

Germinability of *H. cordifolia* seeds is highly variable. Different seed samples sown during the present study gave a germination of 40-91 per cent (Table 4.6.2). Earlier, Nair *et al.* (1991) had reported 54-97 per cent of germination in

trays filled with forest soil. Sengupta (1937) has also reported 90 per cent germination for seed samples from West Bengal.

Table 4.6.2. Details of processing and germination of seeds of *H. cordifolia*

Seed samples	No. of seeds sown/tray	Duration of treatment	Media used for sowing	Quantity required/tray	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Sun dried seeds	1807	1 week	Foam bed	10 g	8	15	1644	91
Sun dried seeds	1750	2 week	Vermiculite	10 g	10	25	1048	59.9
Seeds pre-soaked in water	1685	24 hours	Vermiculite	10 g	12	30	927	55
Stored seeds	1797	1 year	Vermiculite	10 g	15	30	179	40

Nursery pests and control

No pest problem was noticed in the nursery seedlings of *H. cordifolia* during the present study. However, incidence of the leaf roller *Parotis vertumnalis* Guen. (Lepidoptera: Pyraustidae) and the gregarious caterpillar *Epiplima quandricaudata* (Lepidoptera: Epiplimidae) are likely to build up in the nursery and young plantations (Nair *et al.*, 1991), which can be controlled by the application of 0.1% solution of Ekalux 25 EC (Quinalphos).

Nursery diseases and control

Damping-off caused by *Pythium myriotylum* Drechsler, *Rhizoctonia solani* Kuhn and *Fusarium oxysporum* was observed in emerging seedlings in seed germination trays. Disease occurred within 3-5 days after the seed germination and continued up to 20 days. The disease caused 80-90 per cent mortality of the seedlings. The disease occurred in small patches of 5 to 10 seedlings and the patches get enlarged rapidly from periphery, affecting the neighboring healthy seedlings under high soil moisture. The tiny seedlings become necrotic by the infection of the fungi on the hypocotyle and cotyledons. Isolations from

the infected seedlings yielded both *P. myriotylum* and *R.soalni*. Both the fungi are important damping-off pathogens in forest nurseries in Kerala and have wide host range and cause severe damage to the seedling crops. However, in the present study *P. myriotylum* was found as the predominant damping-off fungus and as *H. cordifolia* seedlings exhibit a very slow growth rate during the early nursery phase, most of them succumb to the disease. *F. oxysporum* was found causing damping-off of seedlings raised on polyurethane sheets. Fungicides were screened against the pathogens and Carboxin (0.05% a.i.) was found effective in controlling the growth of the fungi. As a precautionary measure, soil in the germination tray was treated with Carboxin (0.05% a.i.) before sowing the seeds. Incidence of damping-off can be further reduced by application of Carboxin (0.05% a.i.) as soil drench. Seed dressing with Carboxin (@ 2 g/kg seeds) could also reduce the disease incidence in the nursery.

In general, damping-off disease can be effectively managed by adopting proper nursery management practices. Usually, incidence of the disease can be controlled by reducing the water regime in the nursery beds to bare minimum and also reducing the seedling density in the seedbeds. Shade over the seedbeds has to be regulated by using proper shadenets (75%). Since the seeds of *H. cordifolia* is very minute, it is always better to raise the seedlings in small germination trays and then transplanting the seedlings to root-trainers or containers to avoid loss due to pre and post emergence damping-off.

A leaf spot disease caused by *Pseudocercospora* sp. was also recorded in *H. cordifolia* seedlings. The disease appeared as small water-soaked lesions and later spread to form dark brown angular spots. The leaf spot disease is not an important one.

Pricking and maintenance of seedlings

Seedlings in trays raised on foam sheets, attained an average height of 2 cm within a month, whereas those in vermiculate medium were of 1.2 cm height within the same period. The seedlings were pricked by



Fig. 4.6.6. A polypotted seedling of *H. cordifolia*

that time into poly-pots of 20 cm x 10 cm size, filled with vermiculate-soil mixture in 1:1 ratio (Fig. 4.6.6).

Root trainer technology

Due to the minute size of *H. cordifolia* seeds, it is more practical to germinate them in wet polyurethane foam kept in plastic trays and then prick the minute seedlings into root trainers filled with mixed weed compost or coir pith compost, within two weeks after germination. Otherwise, the dibbled seeds in root trainers may be lost during watering, thereby affecting the germination percentage. Probably, this has happened in the present trial also as only 12 per cent of the quantity sown germinated. Almost 100 per cent survival is observed for the seedlings pricked and planted in root trainers with the two types of composts tried. The growth of the root-trainer seedlings is being monitored.



Fig. 4.6.7. IBA treated cuttings of *H. cordifolia*

Vegetative propagation

All the three concentrations of IBA were tried to root juvenile stem cuttings of *H. cordifolia*.

Irrespective of the concentration of the rooting hormone, in all the three experiments, 100 per cent rooting was observed after 15 days in vermiculite filled root trainers (Fig. 4.6.7). Afterwards the rooted cuttings were transferred to the glasshouse for hardening.

Plantation method

Out-planting of seedlings

H. cordifolia, being a species of the moist deciduous forests of Kerala, plantation trial was conducted in the campus of the Field Research Centre of the Institute at Veluppadam. Pits of 30 cm x 30 cm x 30 cm size were taken at a spacing of 2 m x 2 m



Fig. 4.6.8. Out-planted seedling of *H. cordifolia*

and 545 seedlings in poly-pots were out-planted towards the end of South-West monsoon. At the time of out-planting, seedlings were of an average height of

about 8 cm (Fig. 4.6.8). However, it is recommended to maintain the poly-potted seedlings for about six months in the nursery before out-planting, so that they will attain more size which will improve the survival rate. Nair *et al.* (1991) suggested maintaining the potted seedlings for about 16 months and by that time they attain an average height of 15 cm or slightly more.

Survival of seedlings

Seedlings of *H. cordifolia* registered a maximum survival rate of 70 per cent when they were observed after three months of field planting. However, about 20 per cent of the seedlings perished during the next three months of planting, bringing down the survival percentage to 48 per cent and this was reduced to 44 per cent by the end of eight months (Table 4.6.3) in June 2002. In an earlier experiment reported by Nair *et al.* (1991), performance of the seedlings were

Table 4.6.3. Details of survival and growth of out-planted seedlings of *H. cordifolia*

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	382	163	70	8.6
6 months	262	283	48	8.8
8 months	240	305	44	16.7

better in mixed plantations with few other indigenous species than in pure plantings of *H. cordifolia*. However, mean survival values in 50 per cent and 25 per cent mixed plantations showed only minor variations. Maximum survival was 95 per cent in the mixture of *H. cordifolia* - *Pterocarpus marsupium* followed by 94 per cent in a combination of four indigenous species. Also, performance of the species (*H. cordifolia*) in its pure plantation was better (79%) than in a 50 per cent mixture of *Albizia odoratissima* and *H. cordifolia* (77%).

Plantation pests and control

No instance of pest was noticed in the plantation trial of *H. cordifolia*. However, the gregarious caterpillar *Eplilema quadricaudata* (Lepidoptera: Epiplemidae)

and the leaf webbing caterpillar *Parotis vertumnalis* (Lepidoptera: Pyraustidae) are two potential pests of this species.

Plantation diseases and control

Leaf spots caused by species of *Cercospora*, *Pseudocercospora*, *Corynespora*, *Guignardia* and *Colletotrichum gloeosporioides* were recorded in planted out seedlings. The disease symptoms produced by the pathogens are almost similar except in the case of *C. gloeosporioides*, where the colour of the spots are dark brown with a pale yellow halo. The leaf spots caused by other pathogens are angular dark greyish brown with dark brown to black margin. Severe infection causes premature defoliation. The disease is of minor significance and hence no control measure is required. So far, only a few pathogens have been recorded on *H. cordifolia*. *Cercocladospora adinicola* (Kar et Mandal) Mulder and *Phyllosticta halduana* Chandra et Tandon are the fungi recorded as causing leaf spots (Ramakrishnan and Ramakrishnan, 1947; Chandra and Tandom, 1965).

Growth of seedlings

The field-planted seedlings registered an average height of 16.7 cm during eight months of growth (Table 4.6.3). However, in an earlier experiment with the species, Nair *et al.* (1991) recorded that the mean values of height showed only minor variations in pure and mixed plantations and seedlings in pure plantations showed better growth. Even though maximum height of 104 cm was observed in a 50 per cent mixture of *Haldina cordifolia* and *Xylia xylocarpa*, pure plantations of the species recorded 102 cm as average height. In a 25 per cent mixture of four indigenous tree species, the registered height was 98 cm, followed by a 50 per cent mixture of *Albizia odoratissima* and *H. cordifolia*, recording a height of 93 cm. Minimum height of 92 cm was also observed in two combinations of 25 per cent and 50 per cent mixtures and the combinations were *Albizia odoratissima* - *Grewia tiliaefolia* - *Haldina cordifolia* - *Pterocarpus marsupium* and *Haldina cordifolia* and *Pterocarpus marsupium*, respectively. It is also noted that mean annual height increment was maximum (69 cm) in the pure plantation trial of *H. cordifolia* (Nair *et al.*, 1991). The species performed better in two other mixed plantings also, where 66 cm height increment was observed in a 50 per cent mixture and 65 cm in a 25 per cent mixture.

Conclusions and recommendations

Damping-off disease is a major problem while germinating the minute seeds of *H. cordifolia*. Therefore, the seeds of *H. cordifolia* may have to be germinated in trays using polyurethane foam with regulated water supply and timely fungicide treatment to check damping-off of the seedlings. Root trainer technology and vegetative propagation methods tried were also very successful for the species. There is no potential pest or disease problem in the seed and seedling stages of the species and the out-planted seedlings survived by about 70 per cent initially, which was reduced to 44 per cent later due to drought, trampling and grazing by wild animals. It has also been recorded in a previous study that pure plantations of *H. cordifolia* perform slightly better than the mixtures with other indigenous tree species like *Lagerstroemia microcarpa* and *Xylia xylocarpa* (Nair *et al.*, 1991).

4.7. LAGERSTROEMIA MICROCARPA

(Lythraceae)

Venthekku

Botanical nomenclature

Lagerstroemia microcarpa Wt., Ic. Pl. Ind. Orient. t. 109. 1839. *L. lanceolata* Wall. (Cat. No. 2120. 1828, *nom. nud.*) ex Clarke in Hook.f., Fl. Brit. India 2: 576. 1879. *L. thomsonii* in Engl., Das Pflanzenreich 17: 251. 1903.

Local names

Venthekku, Vellilavu.

Species description

Deciduous trees, 20-30 m high; bark smooth, pale white or ash coloured, peeling off as large, thin stripes; young branches ash coloured with a reddish tinge. Leaves simple, entire, petiolate, broadly ovate, elliptic-lanceolate, broadly elliptic, ovate, elliptic, narrowly elliptic, obovate or broadly obovate, light green, glabrous above, hoary tomentose or glabrous beneath, acute, acuminate, obtuse or rarely cuspidate. Inflorescence axillary or terminal, racemose compounded into trichotomous panicles; flowers white with a reddish tinge. Capsules ellipsoid, yellowish brown, loculicidal with persistent, reflexed calyx lobes; seeds flat (Fig. 4.7.1).



Fig. 4.7.1. A tree of *L. microcarpa*

Distribution

Almost throughout Kerala, in moist deciduous forest tracts, between 400-1000 m above msl; tropical Asia, Australia.

Phenology

Flowers during May to July and fruits mature by December, January or February.

Timber, wood characteristics and uses

Log quality

Main bole is straight and branch-free for most of its part and measure more than 15 m in length and 80 cm in diameter. Fluting is not prevalent, so also buttressing. Other defects are also comparatively rare except for the stumps on the main stem and branches.

Wood properties and uses

Basic density of wood varies from 528 kg/m³ to 657.8 kg/m³, region-wise in the State with an average is 593 kg/m³ (Nazma *et al.*, 1981). The wood is medium-textured, moderately hard, medium heavy (640 kg/m³) and is with straight to somewhat intervened grains. The timber is mainly used for making door and window frames, furniture, railway sleepers, tea chests, boat and ship parts, automobile body parts and as bent wood articles. Textile mills parts, artificial limbs and rehabilitation aids, poles, posts, toys, sports items, etc are also often made of Venthek (Ben-teak).

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection

Ripened capsules are available during January to May and seeds collected during February and March gave maximum germination percentage. The ripe capsules may be collected from trees before they dehisce and fall off. The capsules are to be filled loosely in cloth bags and sun dried. On drying, the capsules break open to release the minute winged seeds, which can be cleaned by winnowing.



Fig. 4.7.2. Fruits and seeds of *L. microcarpa*

Seed characteristics

Fruits are reddish-brown in colour when ripe and ellipsoid in shape, measuring up to 1.4 cm x 0.9 cm. In one kilogram there will be a maximum of 2100 fruits. The seeds are brown in colour, and being very small (Fig. 4.7.2), on an average,

about 2,89,000 to 3,00,000 seeds weigh one kilogram (Table 4.7.1). Reports from Maharashtra, Tamil Nadu and Karnataka show 2,68,082 (Sengupta, 1937), 1,95,380 and 2,67,490 (FRI, 1984) seeds per kilogram, respectively.

Table 4.7.1. Fruit and seed characteristics of *L. microcarpa*

	Colour	Shape	Size cm	No. per kg
Fruits	Reddish brown	Ellipsoid	1.4 x 0.9	2068-2100
Seeds	Brown	Flat	0.5 x 0.3	2,89,000-3,00,000

Seed storage

The cleaned seeds can be stored in gunny bags for about 6 months without loss of much viability (Nair *et al.*, 1991). However, during the present study seeds stored for one year were germinated and data gathered.

Seed pests and control

No instance of pest incidence was noticed in the seeds collected during this study.

Seed diseases and control

A rich spermioplane microflora comprising of 13 fungi and an actinomycete was recorded on the seeds of *L. microcarpa* in blotter tests. *Trichoderma viride*, *Aspergillus* and *Cladosporium* were the only storage moulds recorded on seeds and of these *T. viride* recorded a high RPI (13) (Table 4.7.2). All the other 10 fungi recorded on seeds are potential pathogens, which are capable of causing various diseases in seedlings. *Drechslera* sp., *Fusarium oxysporum*, and *Curvularia lunata* occurred in high frequency and were associated with seed rot and rot of emerging seedlings. *Alternaria* sp. also showed severe infection on seeds and seedlings. Among the ten field fungi recorded on *L. microcarpa* seeds, *F. oxysporum*, *C. lunata*, *Alternaria* sp., and *Drechslera* sp. seem to be seed-borne. Seed dressing with Carbendazim (@ 3 g/kg of seeds) and Captan @ 4 g/kg seeds was found effective in reducing the spermioplane microbes. Earlier, *Aspergillus niger* and bacteria were recorded on the seeds of *L. microcarpa* from Kerala (Mohamed Ali and Sharma, 1989) and suggested Emisan 6 for reducing the incidence of bacteria. However, in the present study, no bacterium was

recorded, except a very low incidence of actinomycetes. In a recent study, Chacko *et al.* (2001) recorded about 23 fungi belonging to 19 genera and actinomycetes on the seeds of *L. microcarpa* collected from different seed zones in Kerala and seed dressing with Captan @ 5 g/kg seeds reduced the fungal infection.

Table 4.7.2. Spermatophyte microorganisms detected on the seeds of *L. microcarpa* by blotter method and their relative per cent incidence (RPI)

Sl. No.	Microorganisms	No. of seeds affected	RPI
1	<i>Aspergillus</i> sp.	7	1.75
2	<i>Alternaria</i> sp.	24	6.00
3	<i>Ascochyta</i> sp.	9	2.25
4	<i>Bipolaris</i> sp.	4	1.00
5	<i>Botryodiplodia theobromae</i>	3	0.75
6	<i>Chaetomium</i> sp.	3	0.75
7	<i>Cladosporium</i> sp.	2	0.50
8	<i>Colletotrichum gloeosporioides</i>	7	1.75
9	<i>Curvularia lunata</i>	32	8.00
10	<i>Drechslera</i> sp.	62	15.50
11	<i>Fusarium oxysporum</i> .	50	12.50
12	<i>Phoma</i> sp.	6	1.50
13	<i>Trichoderma viride</i>	52	13.00
14	Actinomycetes	6	1.5

Seed processing and pre-treatments

Dried and cleaned seeds can be stored in sealed tins or gunny bags. Rai (1999) suggested mixing the cleaned seeds with BHC before storing to get better germination. In the present experiment seeds soaked for 24 hours in water at room temperature were used for germination trials.

Nursery techniques

Seed sowing

About 3.3 g of seeds which will contain about 1000 numbers will be sufficient to sow in a germination tray of 50 cm x 50 cm size. Both foam sheets and vermiculite were used as the media for germination and data gathered were

Table 4.7.3. Details of processing and germination of the seeds of *L. microcarpa*

Seed sample	No. of seeds sown/tray	Duration of treatment	Media used for sowing	Quantity required/bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Seeds sown as such	1000	Dried for 2 days	Foam sheet	3.33g	10	30	102	10.2
Sun dried seeds	1000	1 week	Vermiculite	3.33g	6	25	170	17
Seeds soaked in water	1000	24 hour	Vermiculite	3.33g	15	27	124	12.4
Stored seeds	1000	1 year	Vermiculite	3.33g	20	35	87	8.7

noted separately (Table 4.7.3). Not less than 300 gm of seeds can be sown in a standard nursery bed of 12 m x 1.2 m size (Nair *et al.*, 1991). Seeds may be sown during February or early March.

Seed germination

Very low germination of 2-20 per cent was earlier reported (FRI, 1984) for the species and during the present study the percentage germination recorded is 8.7-17 per cent for different seed samples. Seeds stored for 12 months showed marked decline in germination (8.7%) in the vermiculite substratum whereas, in the same medium, those sun-dried samples sown gave the maximum germination (17%), as given in Table 4.7.3. In fact, sun-dried samples started (sixth day) and completed (twenty-fifth day) germination earlier than seeds treated otherwise.

Nursery pests and control

Incidence of a leaf webbing caterpillar *Phycita* sp. (Lepidoptera: Phycitidae) and a semilooper (Lepidoptera: Geometridae) have been recorded in the study (Fig. 4.7.3). Of these, the latter cut the shoot of the tender seedlings and fed on the foliage. Attack by an unidentified top shoot webber (Lepidoptera: Tortricidae) was also noticed in the nursery. The light reddish coloured caterpillars of this insect webbed the tender leaves and shoots and fed from within. As feeding by this insect caused damage to the terminal shoot, growth was retarded and



Fig. 4.7.4. Leaf webbing in *L. microcarpa*

about 20 per cent of the seedlings suffered by the attack. Leaf weeding by the weevil *Indomias cretaceus* (Faust) (Coleoptera Curculionidae) and incidence of an unidentified mite (Acari) have been recorded earlier in the nursery, causing moderate to heavy damage to seedlings (Nair *et al.*, 1991). Of these, the unidentified species of mite which caused fluffy overgrowth on the leaf surface was the most serious pest. The affected seedlings showed stunting and poor growth when out-planted. Application of dicofol (Kelthane) at 0.05% a.i. at fortnightly intervals effectively controlled this pest. The weevil, *I. cretaceus* attacked the tender foliage of seedlings causing withering of the leaves. Damage by this insect was noticed during the months of August-October. Cotyledons and tender leaves of root trainer seedlings were eaten away by the caterpillar *Semiothisa* species. Looping caterpillars of the species resemble dry stem, often escaping detection. Also, sap-sucking aphids aggregating on the stem and leaves of seedlings cause their stunting. Application of Ekalux 25 EC (0.1%) can control the attacks.

Nursery diseases and control

Damping-off of *L. microcarpa* seedlings caused by *Rhizoctonia solani* was recorded in the seedbed nursery. The disease appeared in small patches affecting 5 to 10 seedlings. Under high soil moisture, the disease spreads in the seedbeds affecting a large number of seedlings. On damped off seedlings, the fungus produce pale yellowish brown small sclerotia. *R. solani* also caused

collar rot in young seedlings; water-soaked lesions appeared on seedling collar region, which later spread and formed large necrotic sunken areas. The affected seedlings toppled down. The diseases caused by *R. solani* were controlled effectively by timely application of Carboxin (@ 0.1% a.i.) as soil drench at weekly interval. Leaf spot caused by *Colletotrichum* state of *Glomerella cingulata* was also recorded from the seedbed and container nursery. The disease appeared as small reddish brown circular lesions with off white margin. As the disease was of minor significance, control measure was not adopted. Damping-off caused by *R. solani* is the major disease in forest nursery (Sharma *et al.*, 1985; Mohanan, 2000) and various control measures including biological control have been suggested (Mohanan, 2001). Earlier, *R. solani* causing damping-off of *L. microcarpa* seedlings has been recorded by Mohamed Ali and Sharma (1989).

In the nursery seedbed, a mosaic disease affecting the foliage of seedlings was recorded. The disease affected both young and mature leaves and showed mosaic symptoms of pale green to white irregular patches (Fig. 4.7.4). The diseased seedlings did not show any retardation in growth. As the disease incidence was very low, affected seedlings were removed from the seedbeds.



Fig. 4.7.4. Seedling mosaic disease in *L. microcarpa*

Pricking and maintenance of seedlings

The seedlings can be pricked out into polythene bags of 12.5 cm x 17.5 cm size, when they attain an average height of 4-6 cm (Fig. 4.7.5). The poly-potted seed-



Fig. 4.7.5. Seedlings of *L. microcarpa*



Fig. 4.7.6. A poly-potted seedling of *L. microcarpa*

lings can be maintained in the nursery for 3-4 months with regular watering and monitoring of disease and pest attacks (Fig. 4.7.6). When maintained in the shaded nursery sheds, it is better to keep the seedlings in open sun for about 3-5 days with regular watering before they are field planted.

Root trainer technology

Dried seeds were dibbled in root trainers filled with mixed weed compost and coir pith compost. Germination started by about 10 days in both the compost samples, and after 30 days, 32 per cent germination of the seeds in the coir pith compost (Fig. 4.7.7) and 30 per cent germination in the mixed weed compost medium was observed.

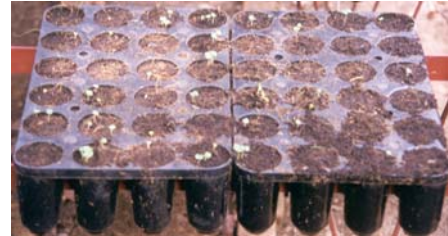


Fig. 4.7.7. Germination of *L. microcarpa* seeds in root trainers

Vegetative propagation

Three concentrations of IBA were tried to root juvenile stem cuttings of *L. microcarpa* (Fig. 4.7.8). Rooting was maximum (60%) in 5000 ppm concentration. In 4000 ppm trial, 45 per cent of the cuttings and in 3000 ppm treated samples, 35 per cent rooted.



Fig. 4.7.8. IBA treated cuttings of *L. microcarpa*

Plantation methods

Out-planting of seedlings

Seedlings which attain an average size of 10-12 cm by about 4 months can be out-planted during the monsoon period. For that a plantation plot was prepared in the Campus of the Field Research Centre of the Institute at Veluppadam in Trichur District. The cleared area was aligned and staked and pits of 30 cm x 30 cm x 30 cm size were taken at a spacing of 2 m x 2 m. The poly-potted seedlings (560) were field-planted and protected from external disturbances for data collection (Fig. 4.7.9).



Fig. 4.7.9. Out-planted seedling of *L. microcarpa*

Survival of seedlings

Almost 52 per cent of the out-planted seedlings survived till three months and this was reduced to 48.5 per cent towards the end of sixth month. The casualties were mainly due to heavy grazing by deer. After eight months only 40 per cent of the field-planted seedlings survived due to this.

Table 4.7.5. Details of survival and growth of out-planted seedlings of *L. microcarpa*

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	291	269	52	19.8
6 months	272	288	48.5	20
8 months	224	336	40	34

Plantation pests and control

In the field planted seedlings, no major pest incidence was noted in the initial stage of growth. However, mild leaf feeding by a few unidentified insects was noticed on 76.5 per cent of the seedlings planted in the field. In addition to this, a weak build up of the leaf webbing tortricid caterpillar was also noticed on some seedlings. The caterpillar characteristically fed beneath a silken web on the leaf surface causing wilting of the foliage and drying up of the terminal bud. Mild attack by a lycacnid caterpillar has also been observed in field-planted seedlings.

Plantation diseases and control

In plantation, minor leaf infections caused by *Colletotrichum gloeosporioides*, and species of *Alternaria*, and *Guignardia* were recorded. Leaf necrosis and withering of leaves was also recorded on a few planted out seedlings and *Fusarium semitectum* was isolated from the diseased tissue. Even though, a large number of fungi causing various diseases in different species of *Lagerstroemia* have been recorded from India, so far, only a few fungi including *Rytisma lagerstroemiae* Rabenth and *Sphaeceloma lagerstroemiae* Wani et Thirum. were recorded on *L. microcarpa* (Rabenhorst, 1878; Uppal *et al.*, 1935).

Growth of seedlings

After eight months, the field-planted seedlings attained an average height of 34 cm (Table 4.7.5). Earlier Nair *et al.* (1991) registered a height of 82 cm within 12 months and the Mean Annual Height Increment (MAHI) was noted as 67 cm in pure plantations of *L. microcarpa*.

Conclusions and recommendations

The seeds of *L. microcarpa* can be germinated both in nursery beds and also soaked polyurethane foam sheet kept in plastic trays. However, germination percentage of seeds is rather very low varying from 8.7 per cent for stored seeds and up to 17 per cent for fresh, sun-dried seeds. In the case of vegetative propagation 60 per cent of the cuttings rooted in 5000 ppm of IBA. Mild attack of pest and diseases, mostly in the nursery, is noted which can be managed by the application of pesticides and fungicides as recommended in the report. Even though, field planted seedlings survived by 52 per cent after 3 months of planting, drought and grazing by deer had brought down the survival of the seedlings to 40 per cent after 8 months of planting in the natural habitat of the species, ie. moist forests of the State. Therefore, shade in the initial stage of seedling establishment and protection from grazing are necessary for better survival of out-planted seedlings.

4.8. MELIA DUBIA

(Meliaceae)

Mala-veppu

Botanical nomenclature

Melia dubia Cav., Diss. 7: 364. 1789. *Melia composita* Willd., Sp. Pl. 2: 558. 1799. *Melia superba* Roxb., Fl. Ind. 2: 396. 1895. *Melia azedarach* L., Sp. Pl. 384. 1753. (*pro parte*).

Local names

Mala-veppu, Kattu-veppu.

Species description

Trees, 20-30 m high; bark rough, peeling off as stripes; young parts scurby-tomentose, glabrous when mature. Leaves bipinnate or tripinnate with 3-8 pairs of pinnae; leaflets ovate-lanceolate to ovate-rotund, entire, serrulate or crenate-serrate, thickly coriaceous, oblique at base, acuminate apex. Inflorescence subterminal panicles, mealy with stellate hairs. Flowers greenish white, fragrant; calyx 5-lobed, lobes ovate-oblong, tomentose; corolla with 5 petals, linear, spatulate, concave, pubescent outside, puberulous inside; stamens 10, monadelphous with the staminal tube white, gibbous at base, bearing exserted and pubescent anthers; pistil with 5-loculed ovary, style little longer than the staminal tube and cylindrical and 5-toothed stigma. Drupes yellowish, ovoid or ellipsoid, pulpy, 1-6 seeded; seeds black, ovoid, with long hard endocarp (Fig. 4.8.1).



Fig. 4.8.1. A tree of *M. dubia*

Distribution

Moist deciduous forests of Kerala, sometimes grown as avenue trees; India, Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, Sri Lanka.

Phenology

Flowers during February to April when the trees shed their leaves and fruits ripen during November to February in the next year.

Timber, wood characteristics and uses

Log quality

Logs large sized, attaining up to 30 m in length and about 143 cm in diameter at breast height (FRI, 1981).

Wood characteristics and uses

The sapwood is grey or pinkish-white with an yellowish tinge and the heartwood is light red in colour. The wood is moderately hard and 450 kg/m³ in weight (Nazma *et al.*, 1981). It is straight grained and coarse textured. The wood is easy to saw, machines satisfactory and can be finished into a smooth surface. It is only moderately durable, that too under cover. It is used as plywood for making packing cases, boxes, crates, etc and for the manufacture of match splints and boxes, cigar boxes, and such light-weight items. Wall-boards, door panels, furniture, agricultural implements and floorings are also made with the wood. Extracts from the tree are medicinal and the leaves are lopped as fodder. The seeds are reported to contain linolic and oleic acids (65-82%) and they also yield greenish-yellow butter oil, not utilized now but potential in preparation of soap and hair oil.

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection



Ripened fruits fall on the ground which can be gathered by clearing the floor below the fruiting trees. Both immature (green-coloured) and ripened (yellow coloured) fruits fall on the ground and only the yellow coloured ones are to be gathered and used for germination (Fig. 4.8.2). The fruits are to

Fig. 4.8.2. Fruits of *M. dubia*

be macerated and depulped for the extraction of seeds and beating with a wooden piece or pounding in wooden mortars is suggested (FRI, 1981) for this.

Seed characteristics

Mature fruits are yellow in colour and are of the average size of 2.8 cm x 2 cm and about 130-140 of them weigh one kilogram (Fig. 4.8.3). Samples with 250-300 fruits per kilogram are also reported (FRI, 1981). On removing the fruit cover, the seeds of an average size of 2.5 cm x 1.1 cm, black in colour, which weigh 800-850 per kilogram (Table 4.8.1) are available for germination.



Fig. 4.8.3. Seeds of *M. dubia*

Table 4.8.1. Fruit and seed characteristics of *M. dubia*

	Colour	Shape	Size (cm)	No. per kg	Methods of storage
Fruits	Yellow	Ellipsoid	2.8 x 2	132-140	In gunny bags
Seeds	Black	Ovoid	2.5 x 1.1	800-850	In gunny bags, plastic bags, sealed tins, etc.

Seed storage

The fruits are to be depulped and the seed cleaned by washing in water. The seeds extracted are to be sun-dried for a few days in shade. In the present experiment, fresh dry seeds were sown in the nursery without storage. However, it is reported that cleaned and dried seeds can be stored in gunny bags or sealed tins for one or more years without losing much viability and Rai (1999) recommended to dress the seeds with 50 per cent BHC before storing. Storing the seeds for one year is also reported to increase the germination rate (Rai, 1999).

Seed pests and control

No instance of pest incidence was noticed in the fresh and stored seeds of *M. dubia*.

Seed diseases and control

Seeds of *M. dubia* were found infested with a rich microflora comprising of 12 fungi belonging to 11 genera and also one bacterium. The storage moulds recorded include species of *Aspergillus*, *Cephalosporium*, *Chaetomium globosum*, *Penicillium* and *Trichoderma* and their RPI were found comparatively higher than that of field fungi (Table 4.8.2). Among the field fungi, *Fusarium*, *Phoma* sp., and *B. theobromae* are the important ones which were found associated

Table 4.8.2. Spermoplane microorganisms detected on the seeds of *M. dubia* by blotter method and their relative per cent incidence (RPI)

Sl. No.	Microorganisms	No. of seeds affected	RPI
1	<i>Aspergillus flavus</i>	39	19.5
2	<i>Aspergillus niger</i>	12	6.00
3	<i>Bipolaris maydis</i>	3	1.50
4	<i>Botryodiplodia theobromae</i>	9	4.50
5	<i>Cephalosporium</i> sp.	8	4.00
6	<i>Chaetomium globosum</i>	15	7.50
7	<i>Colletotrichum gloeosporioides</i>	6	3.00
8	<i>Fusarium</i> sp.	16	8.00
9	<i>Penicillium</i> sp.	14	7.00
10	<i>Periconia</i> sp.	2	1.00
11	<i>Phoma</i> sp.	6	3.00
12	<i>Trichoderma</i> sp.	32	16.00
13	Bacteria	4	2.00

with seed and seedling rot. In a recent study on spermoplane microflora of *M. dubia* seeds collected from different seed zones in Kerala, Chacko *et al.* (2001) reported 19 fungi, bacteria and actinomycetes. *Myrothecium* sp., *Fusarium oxysporum*, and *Colletotrichum gloeosporioides* were recorded as causing seed

and seedling rot. Seed dressing with Captan (@ 4 g/kg seeds) is recommended for reducing the spermiplane microflora.

Table 4.8.3. Details of seed samples sown and their germination percentage

Seed sample	No. of seeds sown/bed	Duration of treatment	Quantity required/bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Fruits sown as such	500	Nil	3.7 kg	Nil	Nil	Nil	Nil
Seeds sown as such	1000	Sun dried for 2 weeks	1.33 kg	90	150	30	3
Seeds presoaked in water	200	24 hour	0.26 kg	55	150	8	4
Seeds presoaked in hot water (60-70°C)	200	1 hour	0.26 kg	45	120	10	5
Seeds soaked in boiling water	200	30 minutes	0.26 kg	45	120	6	3
Seeds soaked in H ₂ SO ₄	100	1 hour	0.13 kg	45	90	6	6
Seeds roasted to 50°C	1000	5 minutes	1.33 kg	35	90	103	10
Seeds soaked farmyard manure	1000	7 days	1.33 kg	45	90	142	14
Seeds collected from spittings of deer	105	Nil	0.14 kg	30	45	19	18
Stored seeds	950	1 year	1.2 kg	45	120	76	8

Seed processing and pretreatments

Melia seeds, in general are very poor in germination when they are tried in the nursery. Therefore, apart from the usual method of sowing dried seeds without any pretreatment, hot-water treated (60-70 °C), boiled water treated (100 °C), those roasted at 50 °C for 5-10 minutes and samples dipped in concentrated Sulphuric acid (H₂SO₄) were also tried to assess the differences in the germination rate due to such treatments. Seeds collected from the spittings of deer were also tried in the nursery experiment and the germination percentage

recorded. Rai (1999) reported the soaking of seeds in cow-dung slurry for two days, in which case, the germination per cent obtained was 15-20 per cent. It is also suggested to break the hard seed cover before soaking in cow-dung slurry. Cutting the hard endocarp of seeds, burying the seeds in pits for about a year and soaking seeds in cold water for a week are also suggested (Chacko *et al.*, 2002) to improve the germination rate of *M. dubia* seeds.

Nursery techniques

Seed sowing

Cleaned and dried untreated and treated seed samples (as mentioned earlier) were sown in the shaded nursery bed, in drilled lines, 10 cm apart. About 7 kg of dried seeds containing about 1000 numbers are required for one standard nursery bed. The seeds sown were watered regularly. To facilitate germination, after sowing seeds in the nursery bed, burning 7.5 cm thick layer of litter above it and then covering with soil with regular watering (FRI, 1981) is also suggested.

Seed germination

In the present trial, seeds without any pretreatment registered a germination rate of 3 per cent after 3 months and germination is yet to be completed. Fruits sown as such failed to germinate and the roasted seed samples gave about 10 per cent germination. Acid treatment gave 6 per cent germination and boiled and hot water (60-70 °C) treated samples are yet to germinate. Seeds gathered from deer spittings gave a germination of 18 per cent within 30 days after sowing (Table 4.8.3) and Rai (1999) reports a germination rate of 60-75 per cent within 35 days, for those seed samples collected from the droppings of goats. Also, 1.5 to 50 per cent germination is recorded for untreated seeds (FRI, 1981) within 48 days (Fig. 4.8.4).



Fig. 4.8.4. Seedlings of *M. dubia* in nursery bed

Nursery pests and control

Sap sucking by scale insects, leaf mining by an unidentified dipteran, leaf webbing by a pyralid caterpillar and top shoot boring by a phycitid caterpillar were the damages noticed. However, none of the above was serious and hence did not affect the survival of the seedling. Also, very stray incidences of attacks by mealy bug was noticed in the nursery seedlings, causing mortality, which can be controlled by the application of 0.05% solution of Nuvacron 36 EC (Monocrotophos) (Fig. 4.8.5).



Fig. 4.8.5. Mealy bug attack on *M. dubia* seedlings

Nursery diseases and control

In seedbed nursery, collar rot and seedling web blight caused by *Rhizoctonia solani* were recorded. The disease appeared as water-soaked lesions on seedling stem at collar region, which spread longitudinally and became necrotic in due course. The infection also affects the apical portion of the seedlings, viz. stem and foliage and showed the typical symptoms of web blight. Water-soaked lesions appeared on lower leaves, which coalesced and spread to the entire leaf lamina. The affected leaves became necrotic and caused premature defoliation. The mycelial web of *R. solani* entangling the foliage can be seen under high humid conditions. *R. solani* is the major forest nursery pathogen in Kerala, and it occurs in different Anastomosis Groups (Mohan, 2001) of varying virulence. Soil-borne as well as aerial strains of *R. solani* cause web blight and the severity of the disease depends on various factors including the nursery conditions. The disease can be controlled effectively by application of Carboxin (@ 0.1% a.i.) as soil as well as foliar drench at weekly interval. Leaf spots caused by *Colletotrichum dematium* (Pers. ex Fr.) Grov. and *Cylindrocladium ilicicola* (Hawley) Boedijn & Reitsma are the other diseases recorded on *M. dubia* in nursery. The symptoms produced by both the pathogens are almost similar; disease appeared as small pin prick lesions, pale brown in colour, later coalesced and spread to form circular necrotic lesions. In severe case, the infection spreads to the entire leaf lamina. Premature defoliation was noticed in container seedlings. Heavy sporulation of *C. ilicicola* occurred as white powdery

structures on the diseased tissues, under high humid conditions. Both the foliage diseases were controlled by the application of Carbendazim (@ 0.1% a.i.) as foliar spray at fortnightly interval for twice. So far, information available on diseases affecting *M. dubia* is very meagre. Earlier, *R. solani* causing seedling blight has been recorded from North-eastern States (Mehrotra, 1989). *C. dematium* and *C. ilicicola* reported herein are new pathogen records for *M. dubia*.

Pricking and maintenance of seedlings

The seedlings in the nursery bed, by about 2 months, can be pricked and poly-potted. The potted seedlings can be maintained in the shaded nursery with regular watering for normally 5-6 months or even up to one year (Rai (1999), before they are field planted during the rainy season (Fig. 4.8.6).

Root trainer technology

Fresh, dried seeds of *M. dubia* were sown in mixed weed compost and coir pith compost filled root trainers. Almost 3 months after sowing only 3 per cent germination was recorded in both the media. The experiment is continued to gather details, if the seeds germinate in due course.



Fig. 4.8.6. A poly-potted seedling of *M. dubia*

Vegetative propagation

Juvenile stem cuttings, branchlets and mature branches of *M. dubia* were tried for rooting or sprouting with the three concentrations of IBA (Fig. 4.8.7). The juvenile stem cuttings tried with 5000 ppm gave about 50 per cent rooting



Fig. 4.8.7. IBA treated cuttings of *M. dubia*

whereas, in 4000 ppm samples, this was 25 per cent and in 3000 ppm treated samples, almost 35 per cent of the cuttings rooted. For other plant samples tried, the results are not yet available, as it may require more time to root or sprout.

Plantation methods

Out-planting of seedlings

Being a species of deciduous forests, the field trial was conducted in the moist deciduous forest area of the Campus of KFRI Field Research Centre at Veluppadam in Trichur Forest Division. The area was cleared of weeds and other miscellaneous growth and aligned and staked at 2 m x 2 m space. Pits of 30 cm x 30 cm x 30 cm were taken and 480 poly-potted seedlings were planted after removing the polythene container (Fig. 4.8.8).



Fig. 4.8.8. An out-planted seedling of *M. dubia*

Plantation pests

No incidence of pests was noticed in the field planted seedlings of *M. dubia*.

Plantation diseases

In out-planted seedlings of *M. dubia*, no major disease was recorded. Die-back of planted out seedlings was noticed and physiological stress due to drought may be the possible reason for the large-scale mortality. *Colletotrichum dematium* and *Botryodiplodia theobromae* were found associated with the dried up shoots. Even though, *C. dematium* was found associated with leaf spot disease in nursery, both the fungi were suspected to be secondary invaders of the dried up shoots.

Survival of seedlings

After three months of planting, 62.5 per cent of seedlings survived (Table 4.8.3) and this was again reduced to 43 per cent towards the end of six months. The

Table 4.8.3. Details of survival and growth of out-planted seedlings of *M. dubia*

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	300	180	62.5	17.4
6 months	206	274	43	18.4
9 months	149	331	31	24.8

casualties were mainly due to heavy drought. After nine months, the survival percentage of field-planted seedlings was still reduced to 31 per cent.

Growth of seedlings

The field-planted seedlings registered an average height of 24.8 cm within nine months, covering the summer season also.

Conclusions and recommendations

As the seeds of *M. dubia* are poor in germination, different treatments were tried and maximum germination (18%) was obtained for seeds gathered from the spittings of deer. Seeds soaked in farmyard manure also gave about 14 per cent germination. There are no potential pest or disease problems in the nursery of the species. The field-planted seedlings survived by 62.5 per cent after 3 months of planting which was reduced to 43 per cent after 6 months and 31 per cent by 9 months. This is because the seedlings are drought sensitive. When field planted, sufficient shade has to be ensured for better survival and growth of *M. dubia* seedlings. Vegetative propagation tried for the species with juvenile stem cuttings appears to be quite promising for the production of propagules.

4.9. *VATERIA INDICA*

(Dipterocarpaceae)

Vella-payin

Botanical nomenclature

Vateria indica L., Sp. Pl. 515. 1733. *Vateria malabarica* Blume, Mus. Bot. 2: 29. 1852.

Local names

Vella-payin, Vella-kunthirikam, Paini-maram, Prum-paini, Payani.

Species description

Evergreen trees, up to 30 m high; main stem almost cylindrical with smooth and white-grey bark, blotched with white and green, peeling off as thick and rounded flakes; branchlets stellate canascent. Leaves simple, ovate, oblong or elliptic, entire, copper-coloured when young, obtuse or acuminate at apex, subcordate or rounded at base. Inflorescence terminal or axillary in often drooping, corymbose panicles. Flowers white, fragrant; calyx with sepal lobes lanceolate, canascent on both the surfaces; corolla of elliptic-oblong, obtuse, spreading petal lobes; stamens 40-50, with short filaments and almost sessile, glabrous anthers with their connectives extended as appendages; pistil with oblong-ovoid, tomentose ovary, style longer than the stamens and small stigma. Capsules pale brown, ovoid-ellipsoid or oblong, 3-valved; seeds one in each fruit, thin walled with two cotyledons, closely and pressed to the fruit wall (Fig. 4.9.1).



Fig. 4.9.1. A tree of *V. indica*

Distribution

Moist deciduous, semievergreen and evergreen forests of Kerala and also, often planted as avenue trees; Western Ghats of peninsular India.

Phenology

Flowering during January to April and fruits ripen during May to August.

Timber, wood characteristics and uses

Log quality

Clear logs, up to 15 m length and about 1.4 m girth are common for the tree.

Wood characteristics and uses

Sapwood is creamy white to greyish-white and the heartwood is grey to light yellowish or pinkish, turning brown on exposure. The wood is moderately hard and moderately heavy, ie. 575 kg/m³ (Nazma *et al.*, 1981). The grain is fairly straight to narrowly interlocked and the texture is medium to coarse. The wood is easy to work and finishes to very smooth surfaces. It also peels well. However, as the wood is not durable and the heartwood is very refractory to treatments, it is used only for temporary construction and other general purposes, and also as Class I plywood. Marine plywood, tea chests, black boards, packing cases and temporary boxes are made of *Vateria* wood. It is also reported to be of good pulping qualities for paper making.

The bark and leaf juice are medicinal. A gum-resin called Piney resin, White dammar or Dhupa (FRI, 1980) is available from the bark of the tree, used in varnish industry and for making incense. A semisolid fat is also contained in the dried kernels of seeds, known as Piney tallow, Malabar tallow or Dhupa fat, used in the manufacture of soaps and candles.

PLANTATION TECHNOLOGY

Seed collection, processing and storage

Seed collection

Ripened fruits on standing trees may be collected by lopping branchlets or immediately after falling, when they are pale brown in colour. The seeds inside show viviparous nature and are also sometimes damaged by weevils, which develop inside the fruit at a very early stage of seed setting. The 3-valved, 1-seeded fruits can be manually opened to extract the seeds. It is essential to saw the seeds within 20 days after collection and therefore, extraction of seeds and

their transportation has be done within that period. The weevil affected seeds are to be discarded before sowing.

Seed characteristics

The fruits, which are ovoid to ellipsoid in shape, are of the average size of 5.8 cm x 4.5 cm, when fresh (Fig. 4.9.2). About 23 or 24 fruits of normal size weigh one kilogram and Rai (1999) recorded 50-60 seeds to weigh one kilogram for fruit samples form Karnataka State. Average size of fresh seeds is 4.6 cm x 3.3 cm and 42-44 such seeds weigh one kilogram (Table 4.9.1).



Fig. 4.9.2. Seeds of *V. indica*

Table 4.9.1. Fruit and seed characteristics of *V. indica*

	Colour	Shape	Size cm	No. per kg
Fruits	Pale brown	Oblong	5.8 x 4.5	23-24
Seeds	Reddish white	Ovoid	4.6 x 3.3	42-44

Seed storage

According to Dent (1948) and Kadambi (1957), *V. indica* seeds can be stored in gunny bags for about a month, after which they deteriorate rapidly. However, it is observed that, if the seeds are germinated as early as possible, the germination rate will be higher. During the present experiment, seeds collected were sown within 10 days and the germination rate recorded was very high.

Seed pests and control

The seeds are moderate to heavily attacked by the weevil *Sitophilus vateriae*, and the pest enters the seed at a very stage of its life cycle, when the seed setting takes place from the pollinated flower. They emerge from the ripe fruits as mature weevils



Fig. 4.9.3. Pest attack in seed of *V. indica*

damaging the fruit as such. Sensarma and Thakur (1994) have reported *Alcidodes crassus*, *Sitophilus rugicollis*, *Nanophes dipterocarpi* (Coleoptera: Curculionidae) and *Coccotrypes borasii* (Coleoptera: Scolytidae) as seed pests

of *V. indica* in India. Since the affected fruits can be detected from the gum oozing out, care must be taken to gather unaffected fruits for the extraction of seeds.

Seed diseases and control

Seeds of *V. indica* harboured a rich microflora comprising of eight field fungi and three storage moulds and a bacterium (Table 4.9.2). Interestingly, most of the field fungi recorded on seeds are potential pathogens. *C. quiqueseptatum*, *B. theobromae* and *Bipolaris* sp. were found associated with rotting seeds as well

Table 4.9.2. Spermatophyte micro-organisms detected on the seeds of *V. indica* by blotter method and their relative per cent incidence(RPI)

Sl. No.	Microorganisms	No. of seeds affected	RPI
1	<i>Bipolaris</i> sp.	6	4.00
2	<i>Botryodiplodia theobromae</i>	9	6.00
3	<i>Colletotrichum gloeosporioides</i>	9	6.00
4	<i>Cylindrocladium quinqueseptatum</i>	24	16.00
5	<i>Curvularia lunata</i>	4	2.66
6	<i>Fusarium</i> sp.	2	1.33
7	<i>Penicillium</i> sp.	3	2.00
8	<i>Periconia</i> sp.	2	1.33
9	<i>Phoma</i> sp.	9	6.00
10	<i>Rhizopus</i> sp.	1	0.66
11	<i>Thielavia</i> sp.	5	3.33
12	Bacteria	8	5.33

as the radicle and plumule infection. *Thielavia* sp. was found mostly on discoloured and shrunken seeds. In a recent study, Mohanan and Anil Chandran (2001) have recorded a large number of spermatophyte micro-organisms associated with the seeds of *V. indica* collected from different seed

zones in Kerala. The growing-on tests has proved that most of the field fungi recorded from the seeds of *V. indica* are capable of causing diseases in seedlings. Seed dressing with Carbendazim (@ 6 g/kg seeds) is recommended for reducing the seed rot and infection in emerging seedlings.

Seed processing and pre-treatments

There is no need for any pre-treatment of seeds before sowing, as the germination rate of *V. indica* seeds is quite high. However, dressing the seeds with fungicides will be useful to avoid rotting when sown and watered regularly in the nursery.

Table 4.9.3. Details of processing and germination of the seeds of *V. indica*

Seed samples	No. of seeds sown/bed	Duration of treatment	Quantity required/bed	No. of days to start germination	No. of days to complete germination	No. of seeds germinated	Germination percentage
Fruits sown as such	460	Nil	19 kg	25	50	37	8
Seeds sown as such	480	Nil	11.4 kg	20	30	456	95
Seeds presoaked in water	510	24 hours	11.59 kg	5	20	393	77
Seeds sown in polybags	200	Nil	4.65 kg	10	25	162	81

Nursery techniques

Seed sowing

As the seeds are quite large in size, they can be preferably sown in potting mixture filled polypots (Fig. 4.9.4). However, trials were also conducted by sowing them in nursery beds, to note the difference in germination percentage and also disease and pest incidences. In polypots, one seed each was sown with a thin layer of soil-sand mixture (3:1) above them. In the nursery beds, seeds were sown in drilled lines, 20 cm apart, with a gap of about 5 cm between two seeds. In a standard nursery bed, 500 seeds can be sown which will weigh

about 11 kg. According to Rai (1999), covering sown seeds with leaf-litter gives better germination.

Seed germination

Germination starts within 20 days and will be completed within about 30 days after sowing. Even seed, partially affected by weevil also germinate and the germination was 95 per cent in the nursery beds (Table 4.9.3). In polypots, the



Fig. 4.9.4. Seeds of *V. indica* dibbled in polypots

germination was quicker to start within 10 days and was completed by about 25 days. However, in the present polypot experiment, the germination percentage was only 81, which is quite less than the results obtained from the



Fig. 4.9.5. Poly-potted seedlings of *V. indica*

nursery beds. A sample of seeds soaked in water for 24 hours before sowing gave only 77 per cent germination and when fruits were sown as such, the germination was as low as 8 per cent (Table 4.9.3). It is also reported (Luna, 1996) that germination starts with 2-3 days, once the ripened fruits

fall on the ground and according to Kadambi (1957) *V. indica* seeds take between 27 and 120 days for complete germination (Fig. 4.9.5).

Nursery pests and control

Infestation of the nursery seedlings by the bagworm, *Pteroma plagiophleps* Hamp. was recorded on the foliage. The insect has the potential to assume serious pest status on *V. indica* (Fig. 4.9.6). Also, the incidence of the leaf webber *Rhodoneura* sp. nr. *myrtaceae* Drury. (Lepidoptera - Thyrididae) was noticed in the nursery and this insect was earlier recorded as the pest of *V. indica* in natural stands (Nair *et al.*, 1996). Incidence of a weevil *Indomias hispidulus* Mrshl. which feeds irregularly on the tender foliage of seedlings occasionally cause minor damage to the nursery seedlings. Also, feeding of

leaves by grasshoppers and roots by termites has been noticed in the seedlings of *V. indica* maintained in the nursery (Fig. 4.9.7 & 4.9.8).



Fig. 4.9.6. Infestation by bag-worm in *V. indica*



Fig. 4.9.7. Feeding of leaves by grasshoppers in *V. indica*



Fig. 4.9.8. Dead seedling of *V. indica* by termite attack

Nursery diseases and control

Leaf spots caused by *Cylindrocladium quinqueseptatum*, *Bipolaris maydis*, *Colletotrichum gloeosporioides*, and *Phoma* sp. were recorded in *V. indica* seedlings maintained in the nursery. Leaf spot caused by *C. quinqueseptatum* manifested as small greyish brown water-soaked lesions on upper surface of the leaves. The lesions enlarge under high humid conditions and become necrotic. In the case of leaf spot caused by *Bipolaris maydis*, the spot becomes irregular shaped large dark brown with black margin. *C. gloeosporioides* and *Phoma* sp. were recorded on necrotic lesions on leaf margin and leaf tips. A severe incidence of leaf blight caused by *Alternaria alternata* was also recorded in both seedbed and container seedlings. The disease affected both mature and young leaves and caused fast spreading necrotic areas, which coalesced and spread fast covering the entire leaf lamina (Fig. 4.9.9). Among the seedling diseases, leaf blight was found severe in container nursery and application of Carbendazim (@ 0.2% a.i.) as foliar spray controlled the disease. For the seedling diseases caused by *C. quinqueseptatum*, *C. gloeosporioides*, *B. maydis* and *Phoma* sp. treatment by Carbendazim (@ 0.1% a.i.) at weekly interval is suggested.



Fig. 4.9.9. Leaf blight in the seedlings of *V. indica*

Pricking and maintenance of seedlings

Seedlings in the shaded nursery bed grow very fast and within 3 months they attain an average height of 9 cm or even more. Therefore, the seedlings have to



Fig. 4.9.10. A poly-potted seedling of *V. indica*

be pricked by that time and potted in sufficiently large (22.5 cm x 17.5 cm) poly-bags to accommodate the fast growing seedlings. The poly-potted seedlings grow very well under shade and by regular watering, they can be maintained in the nursery for a maximum of one year (Fig. 4.9.10). Rai (1999) had given details of shoot and root lengths of *V. indica* seedlings raised in nursery beds and polypots at three locations in Karnataka State, during 370 to 398 days of their growth.

Root trainer technology

Due to non-availability of seeds, root trainer technology could not be tried for *V. indica*. However, as dibbling of seeds in polypots, being a better practice than the seed-bed method, root-trainers with sufficient cell space can also be a more convenient method to produce seedlings of *V. indica* on a large scale.



Fig. 4.9.11. IBA treated cuttings of *V. indica*

Vegetative propagation

Juvenile stem cuttings of *V. indica* were tried for rooting with the three concentrations of IBA (Fig. 4.9.11). The maximum rooting of 16 per cent was obtained for the samples treated with 4000 ppm of IBA.

Plantation methods

Out-planting of seedlings

Being a tree of the moist deciduous areas, the plantation trial was conducted in the Campus of the Filed Research Centre of the Institute at Veluppadam in Trichur Forest Division. In the cleared, aligned and pitted plot, 560 poly-potted

seedlings were field planted at a spacing of 2 m x 2 m, in pits of 30 cm x 30 cm x 30 cm size (Fig. 4.9.12).

Survival of seedlings

Almost 90.5 per cent of the out-planted seedlings survived after a period of three months, and since then, there were not much casualties (Table 4.9.3) till the starting of summer months in January. The seedlings were much affected by heat and sun during summer, which brought down the survival to 59 per cent by about ten months. Therefore, it is recommended that, for better survival of seedlings, it is better to raise plantation of *V. indica* in shaded and moist areas or provide with shade at least during the initial 2-3 years after planting in order to ensure high percentage of survival and better growth of the seedlings.



Fig. 4.9.12. An out-planted seedling of *V. indica*

Table 4.9.4. Details of survival and growth of out-planted seedlings of *V. indica*

Period of observation	No. of seedlings survived	No. of seedlings dead	Survival percentage	Average height (cm)
3 months	507	53	90.5	80.9
6 months	347	213	62	81.4
10 months	330	230	59	83

Plantation pests and control

No major pest problem was noticed in the out-planted seedlings.

Plantation diseases and control

No serious disease has been recorded in planted out seedlings, except leaf spot caused by *Pestalotiopsis* sp. and *Colletotrichum gloeosporioides*. Both the fungi were found associated with large dark brown necrotic spots.

Growth of seedlings

Within a period of ten months, the field planted seedlings recorded an average height of 83 cm (Table 4.9.3). Rai (1999) had observed that planting of bare root

seedlings and stumps is not suitable and dibbling of seeds in areas where the species has to be regenerated is a better method than transplanting seedlings. However, Kadambi (1957) had observed that an attempt to regenerate *V. indica* at Nilambur in 1927 was not very successful and only 33.5 per cent of seedlings survived after one year. It may not be possible always to follow the dibbling method, and the standardized pot method can be used without much damage to the roots while planting. Also, as noted by Kadambi (1957), shade in the early stage of growth is very essential for the success of *V. indica* plantations, which is proved during the study.

Conclusions and recommendations

The ripened fruits of *V. indica* are often heavily attacked by a pest called *Stophilus vateriae*, and therefore, they are to be gathered with proper care to get pest-free and viable seeds. Nursery sown seeds of the species gave 95 per cent germination and when directly dibbled in potting mixture filled polypots, about 81 per cent was the germination rate. Vegetative propagation method tried was not promising, as there was only 16 per cent rooting in 4000 ppm IBA tried, which is the maximum. Seedlings in the nursery are often slightly affected by bagworms, termites, etc and also the leaf blight disease, which may have to be monitored for their severity and control measures taken, if essential. The field planted seedlings in the trial survived by 59 per cent till the tenth month after planting and growth rate of seedlings is also quite high. However, the out-planted seedlings have to be protected from severe sun and drought, by providing shade for one or two years after field planting.

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